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A MANUAL

OF

DENTAL PROSTHETICS

BY

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Illustrated with 396 Engravings

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THIS VOLUME

IS DEDICATED TO THE MEMORY OF THE LATE

JONATHAN TAFT, D.D.S., M.D.

AS A TOKEN OF RESPECT AND ADMIRATION FOR THE LIFE AND

WORK OF THE EMINENT TEACHER, PROFESSIONAL

MAN, AND CHRISTIAN GENTLEMAN

THE AUTHOR

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PREFACE

This book has been written in response to the oft-repeated request by teachers and members of the dental profession for a concise modern text-book on Dental Prosthetics. It is the result of the experience gained in thirty-five years of practice, fifteen years of which have been devoted exclusively to prosthetics and thirteen years to teaching in dental colleges. The author hopes it may meet the requirements and merit the approval of both teachers and practitioners.

The desire has been to give the physical and chemical properties of the materials used in as terse a form as consistent with thoroughness, and also to explain the technique sufficiently in detail. Repetitions and the recital of multifarious methods for accomplishing the same end have been avoided. However, it has seemed wise in some instances to vary from this intention as instanced by the space given to the writings of Prof. Gysi. This plan renders it necessary for the reader to peruse the chapters in order, and to refer often to the index, which has been arranged to facilitate correlation of the various phases of each subject.

If it appears that credit has not been given freely, it is because the author makes no claim to originality, and is recording methods and ideas which he has acquired from sources too wide to trace. Their inclusion has not depended on their origin, but solely on their proved value in practice.

The author long since learned that it is hazardous for any man to claim originality, as we are all dependent one upon another. At times he may seem arbitrary and critical, but he is pardonable if he has succeeded in making clear a truth or impressing a fact in the reader's mind.

The author wishes to express his thanks to all who have so generously permitted the use of material or furnished illustrations. He desires especially to mention his indebtedness to Dr. Charles R. Turner, Prof. A. Gysi, and Dr. George B. Snow for the use of their writings; to Dr. Chalmer J. Lyons for illustrations of the cleft palate; to Dr. Harris R. C. Wilson for drawings; to Dr. Guy D. Lovett for reviewing the manuscript; and to the publishers for many courtesies shown.

G. H. W.

Cleveland, Ohio, 1911.

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PROSTHETIC DENTISTRY

CHAPTER I

THE MOUTH

The mouth, from an anatomical point of view, is the entrance to the alimentary canal; and primarily is for receiving and preparing the food for deglutition. In mankind there is a secondary use, that is, to aid in speech and expression. In this chapter the mouth will be considered only in its primary relationship; its secondary function will be treated in the chapter on esthetics.

ANATOMY[1]

The face is divided into three portions, known as the first portion or upper third, second portion or middle third, and third portion or lower third (Fig. 1). These thirds are indicated by four imaginary and approximately parallel lines—the first at the top of the forehead, or normal hair line; the

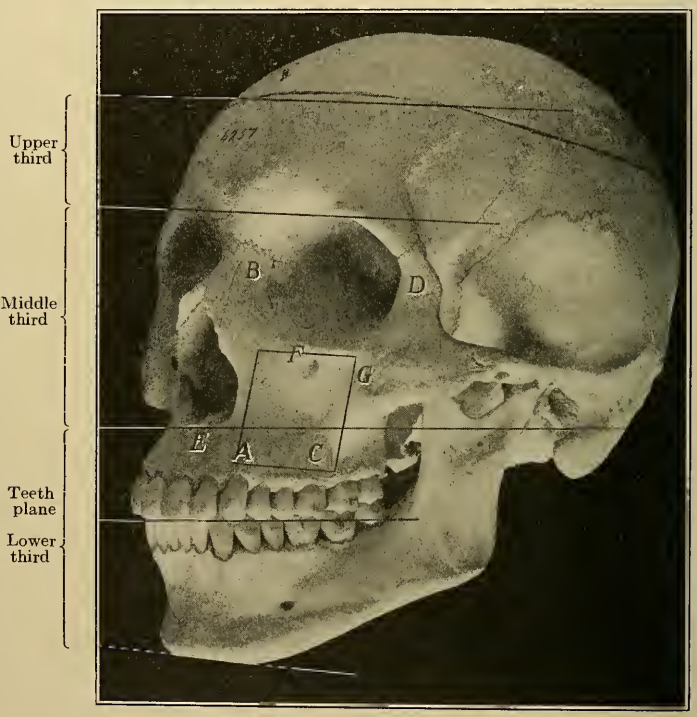
[1] It is not within the province of this monograph to treat in detail either general or dental anatomy; it considers only their practical application. It is assumed that the student has some knowledge of the tissues and organs under consideration; and it is hoped that the practically applied anatomical science will create a desire for an intimate acquaintance with the subject.

For convenience of expression, the singular form of the names of bones and muscles is used, although, with few exceptions, they are in pairs. One side of the cranium is a counterpart of the other

The student is referred to his text-books on general and dental anatomy, and especially to the excellent article, "The Human Dental Mechanism: Its Structure, Functions, and Relations," by Charles R. Turner. M.D., D.D.S., in the third edition of the American Text-book of Prosthetic Dentistry.

second at the junction of the forehead and nose, or a line drawn at the lower border of the crest of the supra-orbital ridges; the third at the base of the nose and extending from the anterior spine of the maxilla to the lower border of the external auditory meatus; the fourth line at the lower

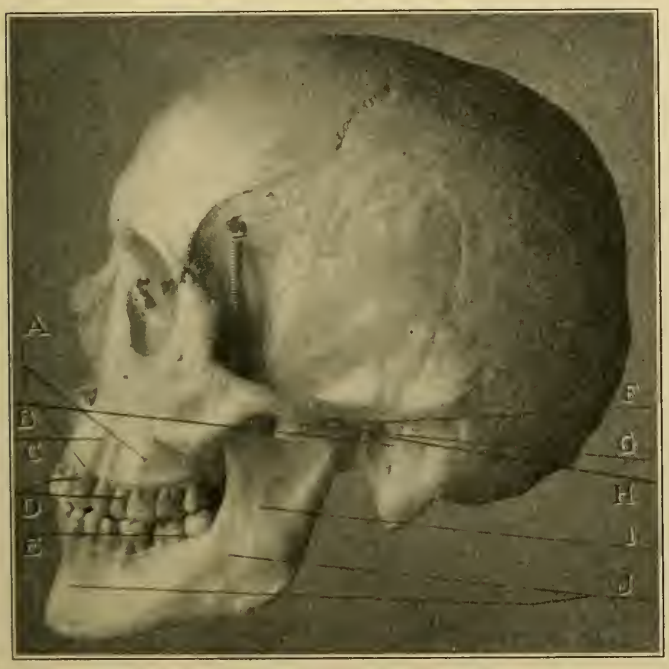
FIG. 1



border of the chin. In passing it may be noted that in the ideal Greek face these thirds are of equal length, but in nature they vary greatly. These lines, however, are very important in the study of the face, for they determine the proportions—whether or not the face is well balanced.

Plane of the Teeth.—The third line, or the naso-auditory-meatus line, is of importance in marking or indicating the plane of the upper twelve anterior teeth (Figs. 1 and 2). It should be noticed that the teeth plane is a straight plane extending from the mesial angle of the upper central incisor to the distobuccal cusp of the first molar; also that

Fig. 2



the teeth plane indicates approximately one-third of the distance from the third to the fourth face line. The teeth plane may be extended backward and it will be seen that the second and third molars are progressively stepped upward. Attention has but recently been called to this fact, so, to satisfy himself of the truth of the statement, the student should not only notice the few illustrations given (Figs. 1 to 6),

but he should observe every normal or nearly normal skull and plaster cast of teeth that opportunity may present. The straight line from the crest of the cusp of the upper cuspid tooth to the crest of the distobuccal cusp of the first molar is assumed by the author to be the foundation of the formation of the dental arch; and the other teeth in the arch are in compensating positions. The four teeth—cuspid, first

Fig. 3

Fig. 4

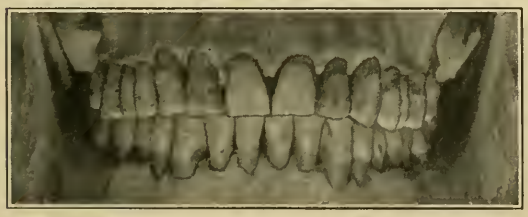
and second bicuspids, and first molar—of an artificial denture may always be placed in this straight line and be considered anatomically normal and mechanically correct.

There is a reason for these four teeth being in a straight line and considered as the foundation of the dental arch. By referring to Fig. 1 it will be seen that the portion of the maxilla in which these four teeth are located has a massive cubical block formation, and that the remaining teeth are

in extensions of this cubical block. The cubical block is outlined by the frontonasal column *A B*, the zygomatic column *C G D*, the infra-orbital arch *B F D*, and the molar arch *A C*. The incisors are in the lower nasal arch *A E*, a forward extension of the cubical block; and the second and third molars are in a tuberosity extending backward from the cubical block. (A cube has the strongest formation and the greatest resistance to force because its dimensions

FIG. 5

FIG. 6



are equal in each direction.) This formation is suggestive that the force of mastication should be upon the area of this cube, and that the straight formation has the greatest resistance to a displacing force applied to an artificial denture.

The scheme presented in this book for antagonizing complete dentures is based upon this fundamental principle.

Curve of Spee.—The curves of Spee and of compensation should be located and thoroughly established. The curve of Spee is an imaginary one, and is described as a segment of

a circle which begins with the incisal edges of the lower incisors, passes over the crest of the buccal cusps of the lower bicuspids and molars, and ends in the anterior border of the condyloid process (Fig. 7[1]). The degree of curvature of this curve of Spee will depend upon the angle of inclination of the eminentia articularis (Fig. 2, *G*). For some years writers and teachers have made this curve of Spee (theoretically) the fundamental principle in the anatomical arrangement of the teeth; and a very elaborate and complicated system of "articulation" has been evolved from it.

Fig. 7

Compensating Curve.—This term has been used as synonymous with the "Curve of Spee." It should not be so used, for the curve of Spee belongs entirely to the mandible, and is anatomical; while the compensating curve is mechanical. The compensating curve (as produced for mechanical reasons) is rarely ever found in nature; but should always be established in complete artificial dentures. The compensating curve is that arrangement of the teeth whereby the so-called three-point contact is established between the upper and lower artificial dentures. If this curve is to be

[1] Fig. 7 from a photograph of a specimen in the Wistar Institute of Anatomy.

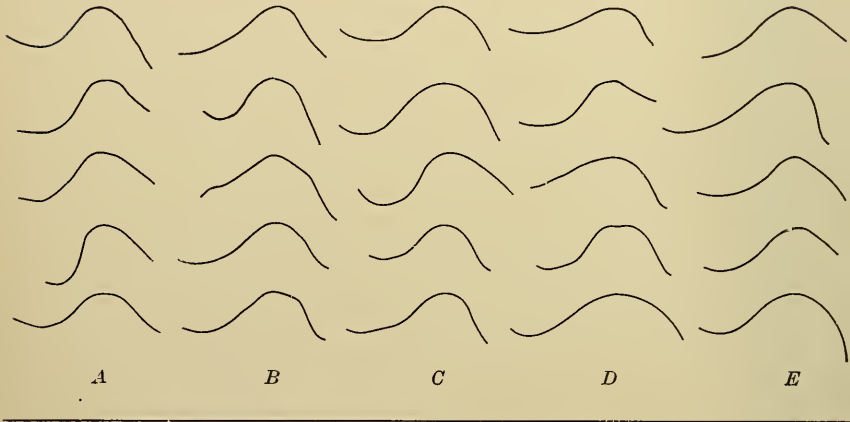
of any practical value, it must be in harmony with the excursions of the condyle. If the articulating surface of the eminentia articularis is horizontal, the condyle moves straight forward in its excursions, and no compensating curve to the teeth plane is required; but if this articulating surface is oblique, as is usual, then the condyle must also descend when it moves forward. This creates a bent teeth plane, and, as has been stated, must correspond with the path of the condyle. If a proper relationship should not be established between the condyle path and the teeth plane, then the artificial dentures will quite likely be dislodged whenever the teeth are occluded otherwise than in the retruded position. The method of obtaining this relationship will be presented in another chapter.

Temporomandibular Articulation.—This is a condylar-thyroidal joint, the structures taking part in it being the glenoid fossa of the temporal bone and the condyle of the mandible, together with the ligaments and the tissues interposed between the bones.

The glenoid fossa (Fig. 2, *F*) is an oblong cavity on the under surface of the squamous portion of the temporal bone, its concavity being directed downward. It is bounded anteriorly by the eminentia articularis, externally by the middle root of the zygoma and the auditory process, and posteriorly by the tympanic plate of the petrous portion of this bone. The anterior two-thirds of this fossa is smooth, and covered, in the recent state, with a dense fibrous tissue, and receives the condyle of the mandible. Of the articular portion of the fossa the distal part is the most concave, and is also the most elevated. From this point it slopes downward and forward to the crest of the eminentia articularis, furnishing a surface over which the condyle glides in the forward excursions of the mandible. The shape of the cavity varies with different nationalities, with different individuals, and sometimes with the opposite side of the same individual. The principal variations are, in size and general concavity, in correspondence with the shape of the condyle, in extent of the surface from the most concave portion of the eminentia

articularis, and in the inclination. The outlines in Fig. 8[1] show the curve of its cavity obtained from skulls after the method of Tomes and Dolamore. The fossa alters frequently in old age, from the pull of the muscles upon the mandible in trying to bring into occlusion teeth that may be widely separated in location.

FIG. 8



Outlines of glenoid fossæ obtained by the method of Tomes and Dolamore. The heavy base line is parallel to a line drawn from the anterior nasal spine to the floor of the external auditory meatus. All the fossæ outlines were on the left side of the skull: *A*, from skulls with typical dentures; *B* and *C*, from skulls with several teeth missing; *D* and *E*, from edentulous skulls.

The condyle of the mandible (Fig. 2, *H*) is the distal upper extremity of the ramus, which fits into the glenoid fossa. The head is an elongated oval body, with its long axis at nearly right angles to the ramus. The head of the condyle is separated from the ramus by an elongated neck, about which strong ligaments are attached connecting the mandible with the temporal bone. The head is separated from the glenoid fossa by a series of tissues that act both as a cushion and a lubricated gliding surface. By this peculiar forma-

[1] Turner's American Text-book.

tion various movements are made possible. The mandible may be carried bodily forward by unison in the movement of the condyle upon either side of the cranium. Whether this movement is horizontal or oblique will depend upon the formation of the eminentia articularis. If one condyle only is moved forward the other will rotate upon its axis, showing the ball-and-socket formation. There is no distal movement of the head of the condyle, except the slight amount that may be produced by compressing the soft tissues covering the head of the ramus. It is the action of the powerful muscles of mastication upon either one or both of the cushioned condyles that makes it impossible to absolutely reproduce the movements of the mandible upon a mechanical frame. However, the latest articulators are so scientifically designed that most excellent results may be secured.

The Mandible.—This is the preferred name for the lower jaw (Fig. 2, *J*). It is often called the inferior maxilla, but this name is becoming obsolete. The mandible is the largest and strongest bone of the face, and serves for the reception of the lower teeth. It consists of a curved horizontal portion, the *body* (Fig. 2, *J*), and two perpendicular portions,the *rami* (Fig. 2, *I*), which join the back part of the body at nearly right angles. The mandible is the movable arm of the dental armament, therefore it is of special interest to the dental student, because of its use and the changes that take place with the loss of the teeth and with old age. Because of its position it is subject to serious accidents and disease, namely, luxations, fractures, and necrosis. The large muscles of mastication are principally attached to the rami, and as the condylar articulation is the only attachment of this bone with the cranium, it represents a lever of the third class. (In the third class the power is between the fulcrum and work.) While this form of the lever has the least power, it admits of the greatest latitude of movement in the mandible, and demands the long and strong muscles of mastication. The length of the muscles is necessary to permit freedom of movement, and their great strength to make possible the easy performance of the work for which

they are designed. That much power is necessary for masticating food can easily be surmised by observing the powerful grip of those animals whose dental armament is not designed for offence and defence. This is well illustrated in the horse, whose small mouth opening prevents the grasping of objects between the molar teeth; but with its incisors it may, in a fit of rage, grip and shake a large man or an animal weighing two or three hundred pounds, as a small terrier would a rat. The power required for man to masticate his food has been experimentally measured by both Professor Black and Dr. Head. Professor Black found that some articles of food require from forty to eighty pounds of force to crush them, while the highest figure obtained by Dr. Head was forty-three pounds.

Muscles.—Muscles are bands or bundles of contracting fibers with two or more attachments. At least one of these attachments may be considered as fixed or stationary. The function of a muscle is to produce motion. The motion is produced by the contracting fibers drawing its movable attachment toward its fixation. As the direction of the force of a muscle is always between its attachments, it must have a counter, because a muscle fiber can produce but one action. Its power is in its contraction. There is no active power in the relaxing of the contracted muscle fiber. There are several groups of muscles attached to the mandible, namely, muscles of mastication, auxiliary muscles of mastication, and muscles of expression.

The temporal, masseter, external and internal pterygoid are classed as the muscles of mastication. They are arranged in symmetrical pairs, and usually operate simultaneously in the movements of the mandible, although each is capable of independent action. They are all attached to the rami, and may be considered as presenting no obstruction to the wearing of artificial dentures. They are the powerful elevators of the mandible. It is through the various inclinations of these muscles, acting in various combinations, that the mandible is protruded, retruded, and rotated. The depression of the mandible is by a different and a much less

powerful set of muscles. The depressors of the mandible are the platysma myoides, digastric, mylohyoid, and geniohyoid muscles.

The auxiliary muscles of mastication consist of the buccinator and the composite muscle—the tongue. So far as the function of these muscles concern the act of mastication, they are auxiliary to the muscles of mastication, and their use is to keep the bolus of food between the teeth. The buccinator (bugle blower) muscle should be given careful consideration, because its action is such that it may seriously interfere with the stability of artificial dentures. Its origin is at the union of the alveolar process with the body of the maxilla. It begins in the proximity of the cuspid (canine) fossa and extends backward to the maxillary tuberosity It is inserted in the corresponding portion of the mandible, or just above the external oblique line. When the teeth have been lost and there is excessive resorption of the alveolar processes, the attachments of this muscle may be very close to the crest of these resorbed processes. In such a case the contraction of the muscle in placing the bolus of food between the teeth tends to dislodge artificial dentures, especially if the buccal flanges of the base-plates are too deep. Sometimes, through carelessness or at least accidents in extracting, and through improper or no after-treatment, false attachments of the muscles are formed upon the process. These cases require that the flanges of the base-plate shall be cut away so as not to impinge, otherwise the false attachment must be surgically removed.

While the function of the tongue, as an auxiliary masticating muscle, is to keep the bolus of food between the teeth, there are a few of its component muscles that need consideration. The mylohyoid is attached to the whole length of the internal oblique line, and forms the floor of the mouth. Sometimes, through excessive resorption, the attachment of this muscle and the crest of the alveolar ridge are in such close proximity that there can be almost no lingual flange to the base-plate of an artificial denture; while with other conditions an extensive lingual flange may be used advantageously.

The geniohyoglossi are attached to the genial tubercles upon either side of the median line. These muscles form not only an important part of the tongue, but their genial attachment, in excessive resorption of the process, form a serious obstacle to the stability of a lower artificial denture. The union of the anterior borders of these muscles, with its mucous membrane covering, forms the frenum linguæ. In no case should an impingement of the lingual flange of the base-plate upon the frenum be permitted. Upon the end of the body of the mandible, that is, at the union of the body with the ramus, is found the mandibular attachments of the superior constrictor of the pharynx. This, and the distal border of the buccinator muscle, in conjunction with the tubercle formed as the result of the resorption of the alveolar process, indicate the extent to which a lower denture may be worn distally. The distal border of the buccinator not only passes between the maxilla and mandible, but also sends some fibers to the pterygomaxillary ligaments. It is these fibers, with their mucous membrane covering, that form the soft, cord-like tissue extending posteriorly from the tuberosity of the maxilla. The upper base-plate should not impinge upon this tissue, as it may dislodge the artificial denture, and also may become very sore.

The muscles attached to the anterior external surface of the mandible, are muscles of expression. Their location may affect the retention of an artificial denture, therefore we will now consider them from this viewpoint. Beginning on either side of the symphysis and extending outward, there are the three muscles, levator labii inferioris, depressor labii inferioris, and depressor anguli oris. These muscles arise at and below the union of the alveolar process with the body of the mandible. In excessive resorption of the process these attachments are so near the crest of the alveolar ridge that very little surface is afforded as a seat for a base-plate. However, the base-plate must be so formed as to cover as large a surface as possible, yet not be displaced by the action of these muscles. At the symphysis is the frenum labii inferioris formed by the blending of a few fibers from

each of the levator labii inferioris and the covering of mucous membrane. Sometimes another frenum is formed just distal to the lower cuspid eminence. This buccal frenum should, when existent, be provided for in the periphery of the base-plate.

Muscles of the Maxillæ.—There are few muscles of the maxilla other than the buccinator that interfere with the retention of the artificial upper denture. The depressor alæ nasi and compressor naris have their origin in the incisive fossa and require attention not only because of their power to displace the artificial denture, but because of their influence upon facial cosmetics. When the alveolar process is largely resorbed the attachments of these muscles are sometimes in close proximity to the alveolar crest. The tendency seems to be for the prosthetist to pad out or bolster up these muscles with the idea of restoring the expression. By studying the origin, insertion, and action of these muscles it will be seen that the desired result cannot be obtained. The endeavor should be not to exaggerate the deformity. The depressor alæ nasi has two fasciculi, the one going to the wing and septum of the nose and the other forming the depressor of the upper lip. These few fibers, in conjunction with a like portion from the other depressor alæ nasi and a well-marked fold of mucous membrane, constitute the frenum labii superioris. When it is recognized that the function of this muscle is to draw in or depress the upper lip and the tip of the nose; that the receding process carries the origin of this muscle farther back than normal, it will readily be seen that any crowding upward of this muscle only tends to still further curl inward the upper lip and the tip of the nose. Therefore, it is necessary that the base-plate shall be well cut away to permit free play of the frenum; and that the flange of the base-plate passing over the incisive fossa shall be well depressed. Otherwise there will be a pouched-out effect of the lip just under the nose. The buccal frenum over the upper first bicuspid must not be impinged upon by the base-plate.

The Soft Palate.—The soft palate (velum palati) is the curtain between the vault of the mouth and the pharynx, and is composed of six pairs of small muscles, each having one of their attachments upon the palate bones. In some cases these muscular attachments will extend farther forward than usual, and in such cases may interfere with the retention of an artificial denture if the base-plate encroaches too much upon them. This same encroachment may not only cause loosening of the artificial denture, but also nausea. However, the base-plate, for best retention, must extend in every direction as far as the muscles will permit, because, other conditions being equal, the retention of artificial dentures is in direct ratio to the square surface covered.

The Teeth.—In the human family the teeth are the hard, flint-like, symmetrical formations placed within the mouth for the purpose of preparing the food for deglutition. They serve also as an aid in speech, but this is a secondary function, and an esthetic rather than an anatomical subject.

It is necessary to study the general characteristics of the natural teeth that we may have a comprehensive appreciation of the demands made upon artificial substitutes.

As the teeth of a skull are viewed in mass they are seen to be in two parabolic rows (Figs. 3 to 6). The upper row is fixed or stationary, while the lower one is attached to a hinged lever (mandible), which carries them into intimate relation with the upper. As these two rows of teeth are held firmly together there is seen to be a method in their form, grouping, and arrangement. Proceeding from the median line in either direction, in the upper jaw, the first two teeth present a straight edge, the next three a single point, and the last three two points each. It is seen also that the upper teeth overlap the lower, and that the mass of teeth viewed as a column has the general form of a truncated cone. The straight-edged teeth are for cutting the food, and are called incisors, central and lateral. The group of three, with one point each exposed when the upper and lower rows are in occlusion, will be found to differ in form when the rows are separated and they are viewed upon

their ends (Figs. 9 and 10). It will be found that the anterior one only has but one point or cusp, and hence is called the cuspid. The remaining two teeth of this group have two

FIG. 9

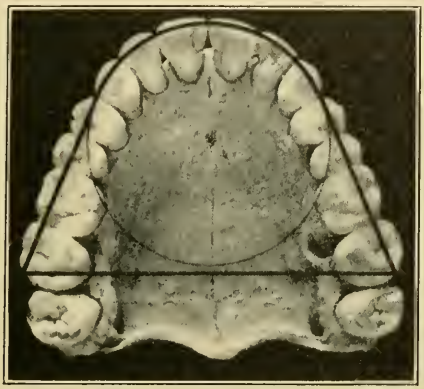


FIG. 10

points, one terminating the outer or buccal surface, and the other terminating the inner or lingual surface. These teeth are called first and second bicuspid (*bi*, two, and *cusp*, point;

two-pointed, bicuspid). The remaining three teeth at the end of the parabolic row will be found, when viewed upon their ends, to have from three to five points, usually four; these teeth are called molars—first, second, and third molars. (Molar is from molaris, belonging to a mill, derived from mola, millstone; molo, grind.) The teeth are, in order, named: central incisor, lateral incisor, cuspid, first bicuspid, second bicuspid, first molar, second molar, and third molar. The names of the teeth are preceded by adjectives denoting location, as right or left and upper or lower. Thus, to indicate a certain tooth, it should be described as right upper central incisor, left lower first molar; that is, first indicate the side of the body, second the jaw, and third the distinctive tooth.

There is another classification that, because of its origin, needs consideration. The Basle Anatomical Nomenclature (BNA) has the highest endorsement of anatomists and biologists. It is in correct Latin and is designed to do away with duplicate anatomical terms. To have one definite name for an anatomical object is most desirable; but for a body of general students to elect terms for the specialist student is apt to be quite unsatisfactory. The author of this book is of the opinion that the specialist student should not acquiesce until his claims have been carefully considered. When brevity and simplicity are the cardinal points of a scheme, it is certainly illogical to adopt the more cumbersome and less significant classification. This is the relation of the BNA tooth classification as compared with the tooth classification of the dental profession. The following is the BNA tooth classification with the English interpretation, as given by Dr. Barker, in brackets: Dentes incisivi (incisor teeth); dentes canini (canine teeth); dentes præmolares (premolar teeth [O. T., bicuspids]); dentes molares (molar teeth); dens serotinus (late tooth [O. T., wisdom tooth]).

There is no good reason for placing the third molar in a class by itself, and the term serotinus (late) is as obnoxious as the obsolete term, wisdom tooth. Premolar is no shorter

than bicuspid, does not describe the tooth as well, and has the disadvantage of having been used by some writers to indicate the deciduous molars. Canine (dog) has no scientific significance. As both classifications will confront the student, he should know the writer's authority and reason for each. This book gives preference to the former rather than the latter classification.

Returning to our observation of the teeth in the skull (Figs. 9 and 10) it is seen that the upper central incisor is wider than the upper lateral incisor, that the lower central incisor is slightly narrower than the lower lateral incisor, and that the upper incisors taken together are much wider than the lower incisors. Dr. Black gives the average width (in millimeters) of the crowns of the teeth as follows:

Central incisor	Upper, 9 Lower, 5.4	Lateral incisor	6.4 5.9	Cuspid	7.6 6.9	First bicuspid	7.2 6.9
Second bicuspid	6.8 7.1	First molar	10.7 11.2	Second molar	9.2 10.7	Third molar	8.6 10.7

This formation permits all of the lower central incisor and half of the lower lateral incisor to occlude with the upper central incisor (Figs. 3 to 6), the lower lateral incisor to occlude with the upper central and lateral incisors, and the lower cuspid to occlude with the upper lateral incisor and cuspid. This arrangement continues throughout the line of teeth. In other words, each tooth, excepting the lower central incisor and upper third molar, occludes with two teeth. This arrangement necessarily places each tooth of the lower row, excepting the central incisor, half of its width (approximately) in advance of its fellow of the upper row. The fact just stated is fundamental, and should be fixed in the student's mind as a landmark. For emphasis, the proposition is restated. *Excepting the central incisor, each lower tooth is approximately half its width in advance of its fellow in the upper parabolic curve.* In arranging the teeth of a complete artificial denture this interlocking of the teeth should always be produced. The teeth should not be arranged end to end, but interlocked one against two.

Farther on the mechanical reasons for this interlocking will be developed.

Parabolic Curve.—A parabola is a section of a cone cut parallel with one of its sides. This will form a figure with a half circle at one end, a straight line at the other, and the ends of the half circle and straight line joined by diverging straight lines. If a skull with typically arranged teeth is held in the hand so as to secure a direct view of the morsal ends of the upper teeth, it will be seen that the teeth describe nearly a perfect parabola (Fig. 9). Dr. Bonwill demonstrated that the segment of the circle described by the six anterior teeth has a radius equal to a line drawn from the mesial incisal angle of the central incisor to the distal incisal angle of the cuspid. The student should appreciate that to study any subject pertaining to nature it is necessary to have an ideal—a type as a standard for comparison. It is an axiom that nature never exactly reproduces herself, therefore science groups the easily recognized modifications of the type into classes.

In studying a large number of human mouths it will be observed that in many cases the segment of the circle will have somewhat of a square form, in others it will be somewhat V-shaped (with apex to the front), and in others a flattened round. This type and the three modifications will be further considered in the chapter on Esthetics, under the heading Temperaments. When the teeth are all *in situ* the radius of the circle may be easily obtained with a pair of dividers, but when the maxilla is edentulous it is another proposition. The next observation is to determine how to secure this radius in an edentulous subject. Upon the skull may be observed an elevated ridge, cuspid (canine) eminence, over the root of the cuspid tooth. This eminence terminates just external to the outer corner of the anterior nares. The student may place his finger upon his own lip over the cuspid eminence and it may easily be felt. By moving the finger upward it will be found that this crest terminates within the triangle formed by the upper border of the lip, the wing of the nose, and the linea nasolabialis. This point indi-

cates the termination of the influence of the cuspid root. Thus, a point of the dividers placed at the centre of the base of this triangle and the other point of the instrument placed in the median line just below the crest of the anterior nasal spine will indicate the length of space to be occupied by the central, lateral, and mesial half of the cuspid tooth. With the dividers so set, and teeth selected to conform with the space indicated, the radius of the required circle can be obtained by extending the dividers to cover the distal angle of the cuspid. In practice it is unnecessary to use the instrument for this purpose, for the wax occlusion model should be so constructed that the cuspid eminence is established by the mouth. The student should remember that this cuspid eminence entirely disappears with the resorption of the alveolar process; so that the labio-naso-buccal triangle is his one guide in determining the width of the anterior teeth; also the radius of the dental circle. (Some operators consider that the angle of the mouth indicates the distance to which the anterior teeth should extend. This is, however, a very unreliable guide by which to determine the width of the anterior teeth, because of its instability and the seeming lack of uniform conformity between the slit of the mouth and the other features of the face.) The prosthetist should establish a mental vision of the segment of the circle described by the anterior teeth and use it as an outline from which to arrange the artificial teeth in each individual case. He should also keep in mind the parallelogram described by the suture of the maxillæ and the cuspid eminence. By continuing the segment of the dental circle it is seen that the line not only passes along the incisal edge of the incisors and cusp of the cuspid, but also through the buccal cusp of the first bicuspid; and then obliquely across the sulcus of the second bicuspid, and across the mesiolingual cusp of the first molar (Fig. 9). In viewing the morsal surface of the upper denture, it will be seen that if a straight line is drawn from the summit of the cusp of the cuspid to the summit of the distobuccal cusp of the second molar, the line will fall across all of the intervening buccal cusps. The third molar is usually

deflected either lingually or buccally from the buccal cusp line. This buccal cusp line always diverges, to a greater or less extent, from the median line of the skull. A view should now be taken of the side elevation of the skull, and it will be seen that the teeth plane is identical with the diverging cusp line. Again, attention is called to the short compensating curve formed only by the elevation of the second and third molars. (Other writers describe a longer compensating curve which includes the elevation of the distal cusp of the first molar, and often of the entire tooth.) Dr. Bonwill and his successors have erred in considering the curve of Spee and the compensating curve equivalent one to the other. Unfortunately, Dr. Bonwill did not recognize the variable condyle path, therefore he could combine his excellent mechanical invention of the so-called three-point contact with the anatomical symmetrical increase of the length of the cusps and overlap of the incisors. This he could not have accomplished with any other than the horizontal condyle path without placing the molars at such an inclination that it would seriously interfere with the retention of an artificial denture. In Dr. Bonwill's "anatomical articulation" the fatal error was made not only in failing to recognize these two important factors, but in endeavoring to reproduce the ideal anatomical formation in place of adapting the changed anatomical conditions to the laws of physics. In contradistinction to the "anatomical articulation" of artificial dentures we shall later present the mechanico-anatomical antagonization of artificial dentures.

Truncated Cone.—In viewing the occluded teeth, as a mass, it will be seen that they present the form of a truncated cone. This is necessarily so because the crest of the alveolar process of the mandible describes a larger circle than the crest of the alveolar process of the maxillæ. This arrangement favors concentrating the bolus of food, by giving a lateral inclination to the grinding teeth, the lowers being inclined inward (Fig. 11[1]) and the uppers being inclined outward. Usually

[1] Fig. 11 from photograph of a specimen in the Wistar Institute of Anatomy.

the incisors, both upper and lower, incline somewhat outward. In some cases the lower incisors incline inward, and in a few instances the upper incisors incline inward, giving a snake-like appearance to the mouth. It is quite probable that this unsightly appearance is the result of the unfortunate loss of the permanent first molars in youth. Too often the dentist gives this unnatural inclination to artificial dentures. It is rarely, if ever, justifiable.

FIG. 11

There is usually an inclination of all the teeth toward the median line of the skull. This is partly due to the conformation of the individual tooth and partly to the tilting of the teeth bodily in that direction. As age and especially as certain diseased conditions progress does this mesial inclination prevail.

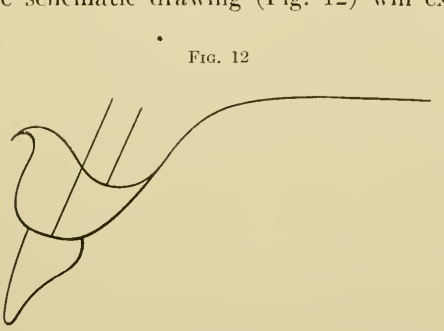
Eruption of the Teeth.—Nature seems to have an admirably adapted plan for the erupting of the permanent teeth. This function begins with the lower first molar, upon each side of the mandible, at about six and one-half years of age. This tooth erupts in the angle formed by the body and ramus of the mandible. It is a wise provision of nature, as it is the most fixed portion of either parabolic curve, and becomes the guide to the eruption and development of the entire dental armament. It is supported by the coronoid column

of the ramus and causes the forward development of alveolar process. As this tooth is in a fixed and fortified position, it directs and sustains the upper first molar through their interlocking cusps. These two teeth upon each side of the mouth being established, the other teeth must assume their normal position and usefulness unless interfered with by abnormal conditions. The dental student cannot too early become imbued with the importance and necessity of preserving throughout life the permanent first molars. The lower teeth are all erupted in advance of their correspondents in the upper dental curve (arch). For this reason some dentists have argued that the lower artificial denture should be set up first, and the upper arranged to the lower. This argument is not tenable, because the reason for the order in which nature places the teeth is entirely different from those confronting the dentist. Nature's foundation principle is to develop the jaws, while the dentist is required to secure mechanical leverage for retention of the artificial substitute. As the maxillæ act as a fulcrum, the upper teeth must be properly and securely placed. The second reason is cosmetic. The upper anterior teeth have much the larger part in establishing the contour and expression, while the arrangement of the lower teeth is little more than mechanical.

The Alveolar Processes.—The alveolar processes are the portions both of the maxillæ and mandible that support the teeth. They develop with the teeth and disappear with their loss. The alveolar processes are removed by resorption. The process of removal is quite active for six months, after which it is much slower for six to twelve months longer, when it is spoken of as a settled or a permanent process upon which an artificial denture may be placed which is designed to be worn for a few years. It is the changing relation of the processes of the two jaws that makes the wearing of artificial dentures so difficult for some people. If measurements were to be made of the crest of the alveolar ridges of the maxillæ and mandible soon after the removal of the teeth, it would be found that the radius of the summit curve would be greater in the mandible than in the maxillæ. This is

evident because of the truncated cone formation of the dental armament. As the long axis of a cross-section of the body of the mandible is divergent from above downward, it is apparent that the radius of its summit curve must increase with its summit recession. While the radius of the summit curve of the mandible is constantly increasing with resorption, the radius of the summit curve of the maxillæ is constantly decreasing, therefore increasing the difficulties inherent in wearing artificial dentures. As the palatal processes are the least changeable of any portion of the maxillæ, the schematic drawing (Fig. 12) will explain why

FIG. 12



the crest of the maxillary process recedes so rapidly inward as well as upward. The two views of the edentulous skull show the result of resorption (Figs. 13 and 14[1]). It is customary to say that where resorption has continued for twelve to eighteen months they are in a permanent condition. This is only relatively so, for the processes may slowly continue to resorb for many years, not only until the surfaces occupied by the alveolar processes are perfectly flat, but until there is an extensive concavity. This is especially true of the mandible. The author, in his practice, has constructed two lower dentures in which a portion of mandibular surface of the base-plate of the artificial denture was convex to the extent of nearly half a circle. This condition

[1] Figs. 13 and 14 from photographs of a specimen in the collection of Dr. M. H. Cryer.

does not imply added difficulties in the retention of the denture, but it does imply decreased substance in the mandible and increased danger of fracture.

FIG. 13

FIG. 14

THE USE OF THE MOUTH

Mastication.—As the first essential for a man is his life, so the first and most important use of the mouth is to prepare the materials of sustenance for deglutition and assimilation. The teeth are most important organs in this operation. The incisors cut off morsels of food of sufficient size for comminuting between the grinding teeth. The bicuspids are designed especially to lacerate fibrous food, while the molars are designed to pulverize and triturate the food with the fluids of the mouth. It is the importance of these organs in preparing the food for its onward movement that creates the dental profession for their preservation, and restoration when lost. The physiology of mastication is beyond the scope of this book, but its importance is so great that the dental student should familiarize himself with the subject to a greater extent, if possible, than the medical student. In fact, the dental student should consider that he is intrusted with the comfort and preservation of the most vital organs of the human economy. It is a lamentable fact that the profession has not yet arrived at that stage of proficiency by which the organs of mastication, in all cases, can be preserved for use and comfort; therefore, the dental prosthetist is necessary to provide a substitute for the lost dental organs. The dentist should appreciate that this office is very important and not one to be thoughtlessly turned over to incompetent hands. The student of prosthetics should delve thoroughly and earnestly into the art, science, and esthetics of restoration that he may properly serve those needing his services.

Speech.—Articulate speech is the means by which man communicates his thoughts. The sounds forming speech are produced by air passing over the vocal cords aided by the resonant chambers of the chest and head. The mouth with the tongue is the most important aid to the vocal cords. The teeth are important factors of the mouth in vocalization, as they give support and shape to the side walls (cheeks)

and tongue. When the teeth are lost, certain muscles must be developed and a greater effort is required on the part of the speaker. With the loss of the teeth there is a permanent loss of certain qualities of resonance and clearness of enunciation that cannot be reacquired by developing the soft tissues. However, by the aid of artificial dentures the original conditions can be so nearly restored that a defect in speech can only be detected by the trained ear. Indeed, in some cases of natural defects and deficiencies of the mouth great improvement of the speech may be made possible by properly constructed artificial dentures and appliances. Artificial dentures may be an impediment to speech, by the base-plate not conforming to the parts upon which they are supposed to rest, thus acting as an edge to split the expelled air of vocalization; or the artificial appliance may be so cumbersome that it fills space required by other factors of enunciation. However, all deficiencies of speech observed in people wearing artificial dentures are not due to improperly constructed substitutes. The personal equation is an important factor. Thus, lisping and whistling are often entirely unnecessary, being faulty conformation of the tongue. Where the prosthetist has satisfied himself that the base-plate is properly fitted and retained, and that there is no unnecessary incumbrance to the movement of the tongue, he should explain and perhaps demonstrate to the patient that the defect in speech is due to the faulty use of the tongue. The proper contour and conformation of artificial dentures will be considered with the technique of construction. The object sought at this time is to establish the fact that artificial dentures are an important factor in both restoring and impeding speech.

RESULTS OF LOSING THE TEETH

Importance.—The importance of the teeth cannot be questioned. Their eruption and retention develop the lower third of the face, and have much to do with cosmetics. They are

useful in the formation of speech and, above all, they are necessary in preparing the intake of food.

Results of Loss.—The loss of one or more teeth in youth will prevent the full development of the face and seriously interfere with the usefulness of the remaining ones. The loss of one or more teeth in adult life weakens the mesiodistal support of the dental armament and exposes a portion of the gum to injury during mastication. The loss of the entire dentures makes impossible the mastication of food. There are a few exceptions to this statement, as there are cases in which the opposing jaws may be brought in contact, and, by use, the gum tissue becomes so toughened that the food can be mashed and insalivated. It is a safe statement to make that the loss of all the natural teeth adds ten to fifteen years to the apparent age of the patient, and it quite likely cuts off as many years of his natural life. It is the province of the operative dentist to prevent these calamities, and the duty of the prosthetist to supply substitutes for the losses sustained by accident, ignorance, or necessity.

The statement is often made that a patient can only use about one-fourth as much force with artificial dentures resting upon soft tissues as could be used with healthful natural teeth. This is probably true, but it should not be assumed that artificial dentures are only one-fourth as effectual as natural ones; because in no case does a patient anywhere near use the maximum of his power in preparing and masticating the food. However, there can be no question but that more time is required to properly insalivate the food with artificial substitutes than with healthful natural ones; and there is undoubtedly more temptation to bolt the food. The loss of the natural teeth should be considered a calamity, but in such a misfortune one should be grateful for the services of the prosthetist.

A word as to the time of removing the natural teeth and replacing them with artificial substitutes. It should be established as a fact that the removal of the natural teeth at any time is more or less a shock and a strain upon the nervous system, and especially so if the patient is in an

exhausted or a debilitated condition. Under such conditions no more teeth should be removed than is necessary to give relief from pain and remove danger of septic infection. The dentist should be very cautious about attempting to construct and insert artificial dentures while the patient is much below par in physical rigor. It is not an uncommon incident for the dentist to be told that "father or mother must have some new teeth, as he or she is failing rapidly." In these cases the dentist should satisfy himself that there is a lack of adaptation of the artificial dentures being worn, and that the unsatisfactory condition is not due to a lack of tone of the tissue, in which latter extremity he cannot be succesful.

EXAMINATION OF THE MOUTH

Seating and Protecting the Patient.—The patient should be seated in a dentist's operating chair, facing a good light. The chair should be adjusted to the comfort of the patient, and tilted slightly backward. A napkin should be fastened about the neck of the patient as a protection to his clothing. If, after examination, an operation is to be performed that may soil the patient's clothing, a further suitable covering for protection should be provided. The mouth mirror and all instruments used about the mouth should be scrupulously clean.

Cleansing the Hands.—Special emphasis is placed upon the cleansing of the hands. Surgical cleansing is not necessary, but mechanical cleansing is imperative. It is not sufficient that the hands have been thoroughly cleansed just before the patient enters the office, but the patient should be conscious that the hands have been laved either just before or just after he or she is seated in the operating chair. The impression produced is most beneficial. The attention given the hands will cause the patient to unconsciously, perhaps, conclude that the instruments are not only apparently clean, but are clean. The dentist should establish a regular course of procedure. His manner should be positive but gentle. These

attentions and methods will have much to do with securing the confidence of the patient.

Method of Examination.—A mouth mirror, an examining point, a pair of cotton tweezers, possibly a blunt probe, absorbent cotton, a supply of aseptic mouth napkins, and a water syringe should be accessible. A compressed air spray is often convenient, but is not a necessity in examinations, for the water syringe will take its place. The operator should stand at the right and slightly back of the patient. This position will give a good view of the mouth, and the person of the operator will not obstruct the light. This position is advantageous for manipulation.

The first glance should observe any inflammatory (sore) condition of the lips, and then of the interior of the mouth, when, if such exists, the operator should endeavor to cause the patient as little discomfort as possible, yet be thorough. Should there be any suspicion of an infectious condition, the operator should use every precaution to protect himself, and after the patient is dismissed every instrument used about the patient's mouth should be sterilized. (Sterilization is taught by another chair, however; when not contraindicated, keeping the instruments submerged for thirty minutes in boiling water will be very effectual.)

With the mouth mirror in the right hand and the assistance of the fingers of his left hand, every portion of the mouth cavern should be brought, in turn, under inspection and investigation. Should the operator observe that there is resistance on the part of the patient, such as moving the head or contracting the lips, he should instantly cast about for an explanation. He should satisfy himself that there is no evidence of filth about his hands or instruments, or that he is not unconsciously pulling the patient's hair, pressing a cuff-button into the ear, handling the mouth in an awkward manner, or causing unnecessary pain. These possibilities of discomfort should in an instant be detected by thought and a glance. Having satisfied himself that he is not at fault, but that the patient is fearful or oversensitive, he should endeavor to overcome these conditions

by his gentle manner and kindly speech. Often the simple request to relax the mouth, expressed in a gentlemanly manner, will be all that is necessary. At other times an assurance that the work in hand does not necessitate pain, an explanation of what is desired, or of the condition found, will place the patient at ease through the confidence gained.

What to Look For.—The things to be observed in the mouth are: Remaining teeth and roots, shape of arches and vault, size of maxillary and mandibular surfaces, extent and condition of the alveolar processes, muscular attachments and glandular tissue, mucous and submucous tissues, and fluids of the mouth. We will consider each of these in the order named.

Teeth and Roots.—A good rule for the dentist to establish is: The difficulties of inserting, and often in using, artificial teeth are in the ratio to the number required. While there are many exceptions to this rule, it is a safe one when considering the advisability of extracting teeth. Another rule is: A base-plate should not be placed over a root unless the root is used as a means for support of the artificial denture. Unused roots are a source of irritation, and usually add to the instability of the artificial denture. However, if the root can be placed in a healthful condition and crowned, or used as an attachment for the artificial appliance, it may be very valuable. The advisability of retaining the cuspid roots as an aid to expression is very questionable, unless they are used for the retention of the artificial denture. In practice, when preparing the mouth for artificial dentures, the operator must often determine whether he will or will not retain one or more sound and firm teeth. In no case should such teeth be removed until their usefulness as a means of retaining the artificial ones has been carefully considered. Sometimes a single tooth is of great value in supporting an artificial denture; especially is this true in the mandible. A single tooth in the maxillæ may be of great value when the conditions are unfavorable for the usual methods of retaining full dentures. Two teeth in either the maxillæ or mandible, if properly located, may furnish the best possible means of

securing the artificial denture. However, a tooth or two may be so located that their retention will be a positive detriment to the wearing of artificial dentures.

It often happens that the patient places much value upon the few remaining teeth, either for their use or cosmetics. If there are two teeth, one in each jaw, opposing each other, it is always doubtful wisdom to remove such; though they may, as they doubtless will, interfere with the retention of artificial dentures. In advising the patient, the dentist must take into consideration that the personal equation is an important factor; that the patient may be one who will never make a success of wearing artificial teeth. However, one factor that the patient should be apprised of regarding the retention of one or more incisors only is that if any movement of the artificial teeth occurs, it is made conspicuous by reason of the stationary condition of the remaining ones. The chapter on retention of artificial dentures will consider the relative value of individual teeth.

Arches and Vaults.—The student should have a clear understanding of these terms. In common parlance, an arch is an upright structure spanning an opening, but this does not apply to the dental arches. The dental arch has reference to the parabolic curve only of the teeth. It is often erroneously used to designate the curve of the roof of the mouth. Such use either shows ignorance or carelessness in the use of accepted dental terms. Vault is the term used to designate the roof of the mouth, the more or less curved span over the tongue. The dental arches are the curved lines described by the teeth of both the maxillæ and mandible, while the vault is the curved line extending from side to side of the mouth, over the tongue.

The shape of the arches and vault will be similar in any given case. Thus, if the upper dental arch is V-shaped, the vault will tend toward the same conformation. This is easily explainable. If in infancy and childhood some influence is brought to bear upon the outer surfaces of the bicuspids and molars (that is, the diverging straight lines of the parabolic curve), so as to compress them, it will also

force the suture of the palatal processes of the maxillæ upward, giving the V-shape to the vault. Any continuous pressure upon the plastic osseous structure of youth will have its beneficial or detrimental effect. Thus, the shape of the dental arches and vault are similar unless they are acted upon by two or more opposing forces. While the shape of the arches and vault are supposed to harmonize with the temperament of the individual, they may be indicative only of abnormalities. The curve of the edentulous alveolar processes and the vault will indicate the curve of the teeth produced through nature, but that is no assurance that the natural teeth were in harmony with the rest of the physical organization. Consequently the curves of the alveolar processes and vault are of much interest, both directly and indirectly, to the prosthetist. The work being done by the orthodontists in bringing the teeth of youth into occlusion is of importance throughout life. It not only helps to preserve the teeth, at least to make them uesful while they are retained, but it puts the mouth in the best possible shape for the retention of complete artificial dentures when such may be required. Some persons may foolishly have sound natural teeth removed because of their unsightly irregularity, and with the intent of having "beautiful" artificial ones inserted. If possible, before the teeth are extracted, the patient should be informed that the conditions of the mouth accompanying the mal-aligned teeth may add to the difficulties of using artificial dentures.

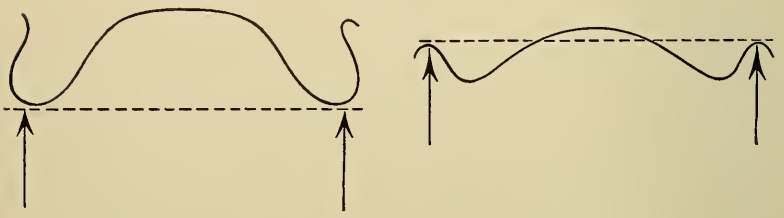
The maxillary suture or raphé requires special attention. This is part of the median line noticed in many portions of the body. Usually it is little more than a slight ridge or fold of mucosa; however, it may develop to the extent of an obstructive osseous tumor the size of a man's thumb. The author's belief (based on experience only) is that these osseous enlargements of the raphé are much more common in the mouths of females than of males. If possible, the base-plate should pass about and not over these excessive enlargements; at least, the pressure must be relieved the entire length of the base-plate; that is, even the posterior

edge must be relieved. A vacuum chamber over any portion of this tumorous surface is more than useless. It only tends to concentrate the pressure upon the remaining portion of the tumor covered. Dr. L. P. Haskell states that 95 per cent. of all cases requiring artificial dentures need the pressure of the base-plate relieved over this portion of the vault.

Size of the Maxillary and Mandibular Surfaces.—The size of these surfaces is not always in harmony with the size of the individual. Sometimes a very large maxillæ is associated with a small physical organization and mouth orifice; at other times the reverse occurs, and occasionally one is large and the other small. These varying conditions will influence the construction and wearing of artificial dentures. These conditions should be well noted in examining the mouth. The size of the maxillæ and mandible is an important factor in retaining artificial dentures; other conditions (shape, soft tissues, tone, and fluids of the mouth) being equal, the amount of retention will be in the ratio to the flat surface (base-plane) covered. In estimating the amount of retention surface that may be of value in retaining a base-plate, only that portion through which direct pressure is brought to bear upon the maxillæ or mandible should be considered. In those cases where the maxillary alveolus flares outward the crest of the alveolus should define the border of the base-plane. The buccal surface of this class of alveolar process will only serve to prevent lateral movement of the base-plate covering it, which, aided by the soft tissues, will exclude the air, and thus be of value in retention. The diagrams (Fig. 15) representing cross-sections of maxillæ will make clear this idea. The arrow points indicate the distance to which direct pressure may be applied, and the dotted lines indicate the relative base-planes. As the base-plates rest upon the soft tissue, it is obvious that pressure brought to bear upon it in the proximity of one arrow only will be concentrated, and tend not only to dislodge the base-plate, but to bruise the supporting soft tissue; while pressure applied at any point approaching the median line will be more diffused over the base-plate, and conse-

quently present greater resistance and better retention. This demonstration shows that the common statement that a flat vault is unfavorable for retaining artificial dentures is not well founded. The poor retention often observed in such cases is due to other causes and often to faulty technique only.

FIG. 15



Alveolar Processes.—An earlier section of this chapter treats of the applied anatomy of the alveolar processes; this section will treat of them as supports for artificial dentures.

When a number of teeth have been recently extracted, in common parlance the gums are spoken of as fresh gums, and when resorption has taken place they are called permanent gums. In a few days (seven to twenty-one) after the teeth have been extracted the gums will have closed over the alveoli, but the gums are not in a condition to withstand much pressure, yet they are in shape for temporary artificial dentures. No matter of what material the base-plate is constructed, when it has been constructed for fresh gums, the artificial denture should be considered as temporary. As the alveolar process recedes it ceases to properly support the artificial denture. The denture may become very insecure, and often irritates the tissues severely. During this process of resorption the base-plate may require refitting once or twice; however, when the artificial denture has been worn from twelve to eighteen months a new one should be constructed. This is necessary to secure proper adaptation of the base-plate and for restoring the contour of the soft tissues.

As the soft tissues (after extraction) close over the alveoli a very irregular surface may present, from portions of the process having been sprung out of position, or possibly fractured to the extent of separation. In such mishaps the loose pieces should be removed at the time of extracting the teeth, or as soon thereafter as discovered; because the detached portion will not be resorbed by the physiological process, but assumes a pathological import. So long as the displaced portion of process is vitally connected with the bone structure, the physiological action will dispose of it. Meanwhile the pressure of a base-plate may be a source of much irritation, and will necessitate cutting away sufficient of the base-plate for relief.

A well-retained artificial denture must have its greatest bearing as near the periphery of its enclosed base-plane as possible.

When the process of resorption is practically complete, several conditions may be present that should be observed. The process may be very prominent, so that the lip is full enough, and the absence of the teeth not noticeable when the patient is not speaking. In such a case, when laughing, the edentulous subject may show from a line to a quarter of an inch or more of the natural gum. Cases of this kind need no artificial gum to restore sunken lip and cheeks. Indeed, they probably present, when not speaking, a much improved appearance from that possessed with the natural teeth. The artificial denture should be constructed without a gum portion as far back as the individual case shall require. This may require no artificial gum over the two central incisors, the four incisors, the incisors and cuspids, or, in extreme cases, no gum portion may be tolerated anterior to the first molars. The artificial teeth in these cases must be ground to set closely against the gum, indeed, press into and apparently grow from the gum. They may be placed with their labial surfaces in line with the crest of the process, or they may be carried outward and lap well over the process. The diagrammatic sketch (Fig. 16) illustrates these conditions.

The vast majority of cases may be classed as regular, and present no complications.

The resorption may continue until the process is almost extinct, when it is classed as flat. The methods of handling these cases will be discussed in technique methods, especially the technique of impressions.

The process when receded may be broad or narrow. The broad alveolar ridge is ordinary, and the thin (knife-edged) ridge is only too common. They are a constant source of annoyance. In time the thin alveolar process disappears, leaving a pendulous, flabby gum. The base-plate should not be permitted to rest upon the sharp edge.

FIG. 16

Sharp ridges may appear upon any portion of the process, especially upon the lingual aspect of the mandible. They will not tolerate the pressure of a close-fitting base-plate.

Nodules from the size of a millet seed to a lima bean, or larger, may appear on any portion of the maxillæ or mandible. If they are to be covered with a base-plate the pressure must be removed from their entire extent. This can be done with one or more layers of No. 60 tinfoil.

Firm or pendulous: The firm gum consisting of an even layer of soft tissue is the desirable condition, but the pendulous and spongy gums indicate complications, and the extent of such complications must be ascertained.

Muscular Attachments and Glandular Tissues.—These may be observed and their obstructiveness may be judged by

distending the cheeks and lips and having the patient raise the tongue to the roof of the mouth. The sublingual and especially the submaxillary glands may interfere with obtaining a perfect impression of this portion of the mandible. The submaxillary gland may entirely cover the bicuspid and first molar portion of the mandible. The impression must be obtained of the surface upon which the gland rests and not of the gland. The method of doing this will be considered in the chapter on Impressions. The muscles and frena attached to the maxillæ and mandible have already been considered, but on examining the mouth the location of their attachments and any obstruction they may present should be carefully observed.

Mucous and Submucous Tissues.—The mucous membrane covers the entire surface of the mouth. It is underlaid with more or less submucous tissue. The condition of these tissues is an important factor in retaining artificial dentures, and requires observation. While all the preceding organs and tissues which we have mentioned for investigation in examining the mouth are inspected by vision, and in a few instances by touch (either finger or instrument), the tissues (mucous and submucous) under consideration can be determined only by the sense of touch. It will be found that in some mouths the mucous membrane is very firm and tense over the whole surface upon which artificial dentures may be worn; in others, that this membrane is largely underlaid with submucous tissue of more or less thickness. It is this class of cases that afford the greatest retention provided other conditions are favorable, and the submucous tissue is not excessive. A third class consists of those cases in which a portion of the surface is covered with tense mucous membrane and other portions are underlaid with submucous tissue. These three classes play an important role in the method of taking impressions, and the method of securing the retention of the base-plate. They should be carefully examined.

Fluids.—The fluids of the mouth consist of a mixture of the saliva and mucous secretion. They may be in moderate amount, or they may be excessive; they may be thin, or

thick and ropy. The thin watery fluid and in moderate amount is the most favorable for good retention of artificial dentures. When the fluid of the mouth is excessive and strings from the mouth as an impression tray or an artificial denture is removed, it may be considered as an unfavorable factor. The thick secretion prevents that close adaptation necessary for the strongest retention.

Recapitulation.—Having a definite knowledge of what conditions may be found in the mouth, the examination is simple and expeditious. Ordinarily no record is made of the examination; however, much valuable information could in time be acquired if blanks were used for systematic work. When the prosthetist examines the mouth he desires to know the conditions presenting, so that he may determine at once whether it is an ordinary or a complicated case. The patient being comfortably seated, and facing good light, the operator makes a momentary visual and digital examination. By this preliminary examination he determines whether there is anything out of the ordinary that may complicate the work; if so, it must be given careful consideration. If he sees no complications, such as inflammatory conditions (sores), undesirable teeth or roots, ill-shaped arches or vault, disproportion between the maxillæ and mandible, unfavorable muscle or frena attachments or gland complication, and no mucous and submucous tissue or fluid complications, he diagnosticates the case as ordinary or simple, with success contingent only upon his technique and the personal equation of the patient. The prosthetist then determines the kind of restoration indicated, whether a bridge or an artificial denture, and the variety of either desirable or permissible. If there are complicating conditions present, he determines whether they are corrective or not, and, if not, how best to overcome the difficulty. Having a clear conception of the requirements of the case, the prosthetist consults with the patient, as the involved expense may be prohibitive. An artificial denture supported upon a base-plate having been determined upon, the next step will be to take a suitable impression.

CHAPTER II

IMPRESSIONS

Defintion.—An impression is a *negative* likeness of an object or part taken in a plastic material, from which a cast or *positive* likeness may be produced.

Scheme.—When the prosthetist determines to construct a base-plate artificial denture, he at once decides upon its general form and extent of surface to be covered with the base-plate. He also forms a tentative plan for retaining the artificial denture. This plan for retention may be altered or abandoned, as a result of a future critical study of the case; nevertheless, a definite scheme must be in mind before taking the impression, because an impression suitable for the contemplated appliance should be obtained. An impression that is most desirable for orthodontia may be entirely inadequate for prosthesis; and certainly an impression that is desired by either the orthodontist or the prosthetist may be distorted for the other. This statement is made to impress the student with the fact that an impression is not necessarily an *exact* negative likeness of a part, but it must be perfect in its suitableness for the work in hand. The soft tissue is the factor that creates the variableness in impressions. Rarely is an impression perfect for its intended use unless the soft tissues are, to a greater or lesser extent, distorted; nevertheless this distortion must be suitable for its intended purpose. The methods herein detailed are for base-plate work. However, there is much in common, in impression taking, for all specialists. The extent of the impression should be governed by the kind of an artificial denture required, whether a partial or full, a saddle, or adhesion base-plate. The impression should extend a little farther in every direction than the contemplated base-plate; but any

excessive extension causes unnecessary discomfort to the patient, and indicates indifference or thoughtlessness on the part of the prosthetist. Therefore, a definite scheme or plan of procedure should be devised for the case in hand, and good workmanship requires that every step shall be neatly and accurately performed. This is a fundamental principle of mechanics, and, as a profession is superior to a trade, the prosthetist should show superior manipulation. Another thought for the young student of dentistry is this: There is no legerdemain associated with prosthesis, the profession being only an expression of cause and effect; therefore, it behooves one to cultivate thoughtfulness and thoroughness in manipulation.

MATERIALS

There are two classes of material used for taking impressions. First, those substances made pliable by heat and that harden on cooling; and second, materials made plastic with water and that harden by crystallization. Wax, modelling compound, and gutta-percha are the materials of the first class, while plaster of Paris is the one material of the second class.

Wax.—Wax is a general term applied to a solid fatty substance obtained from all three of the kingdoms of matter. The general properties of the various substances called wax may be stated thus: They are solid or semisolid substances; are easily broken when cold, but at a moderate warmth are soft and pliable, and fuse at a temperature below 212° F. They have a peculiar glistening appearance, are lighter than water, are insoluble in that fluid and in cold alcohol, but dissolve readily in ether; they are combustible, burning with an illuminating flame, and are non-volatile.

Beeswax.—Beeswax is an animal secretion formed by bees from sugar, and is the material from which the honeycomb is formed. It is obtained by expressing the honey and fusing the residue in water. In this state it is of a yellowish color (Cera flava). It may be bleached, so as to form white

wax (Cera alba), by being exposed in thin slices to the action of solar light. The yellow wax is firm, breaking with a granular fracture, yellowish, having an agreeable honey-like odor; not unctuous to the touch; melts at about 175° F.; is insoluble in alcohol, but dissolves in oil of turpentine, ether, and chloroform. It is of a complex formation, and a number of derivations are obtained from it. $C_{48}H_{92}O_2$ is considered as its general composition.

Vegetable Wax.—These waxes may be obtained from several varieties of plants. They are of no value to the dentist.

Mineral Wax.—This is a natural material known as ozocerite, and is a waxy translucent mixture of the paraffins of coal formations. The paraffins have a chemical formula of C_nH_{2n+2}. The natural mineral wax (earth wax) may be used, but the manufactured mineral wax (paraffin, a by-product of the distillation of coal and petroleum) is extensively used in the dental laboratory. It is used in sheet form as base-plate wax, also combined with beeswax.

Wax is softened for use by heating either in hot water or a flame, and kneading with the fingers. If the wax is to be softened in water, small lumps should be placed in a dish containing a quart or two of cold water, then as the water is heated the heat will penetrate the wax and not melt the surface only, as would be the case if the lumps of wax were placed in hot water. As the wax softens it is removed from the water, dried upon a cloth and kneaded between the fingers until it is smoothly plastic. Should the softened wax become too hard for its intended use it may be again warmed in the water or passed a few times through a smokeless flame. The dry heat method of working wax consists in having the wax from $\frac{1}{16}$ to $\frac{1}{4}$ inch thick and passing it repeatedly through the Bunsen flame and kneading between the fingers. It is reheated and kneaded until it is of the proper plasticity. Should it be overheated upon the surface it will appear crumbly, but soon becomes smoothly plastic by kneading.

Beeswax adulterated with tallow may be detected by the

odor and greasy feeling. Such wax is not suitable for dental purposes.

Wax may be easily made into sheets of any thickness by the dipping method. The wax is melted over water in a double pan (that is, one pan set in a larger pan containing water, thus lessening the danger of ignition); when it is thoroughly melted and any dirt it may have contained has settled, a flat quart bottle containing cold water is dipped into it and instantly removed. When the layer of wax upon the surface of the bottle has chilled, it should be slit upon the sides and at the edge of the bottom of the bottle, when it can be stripped from the glass. Sheets of varying thickness may be made by dipping repeatedly.

Modelling Compound.—This material is a composition of a resinous gum, as copal, dammar, kauri, etc., with stearin and French chalk, colored and flavored. A formula and instruction for compounding, attributed to Mr. E. Lloyd Williams, of London, England, is as follows: French chalk, $1\frac{3}{4}$ parts; kauri, 1 part; stearin, $1\frac{1}{2}$ parts. Melt the stearin in an enamelled pan and stir in the gum. When these are thoroughly incorporated stir in the chalk. This material will be of a yellowish-white color. It may be colored with carmine and flavored as desired. Modelling compound is much used in taking impressions, for trial base-plates, and occlusion and contour models.

Modelling compound is softened in water after the manner described as the wet method for softening wax. The surface of the compound, just before placing in the mouth, should be passed over a flame. As the softened modelling compound is liable to adhere to the bottom of the pan, it is a good plan to place one end of a strip of white paper in the pan for the compound to rest upon. The other end is a convenient means for withdrawing the compound from the hot water.

Gutta-percha (*gatah*, gum; *percha*, the tree from which it is obtained).—The gum is in many respects similar to caoutchouc. The former is only slightly elastic, while the latter has almost perfect elasticity. Gutta-percha is the dried milky juice of a tree, *Isonandra gutta*, growing in the May-

layan archipelago. The material may be had at the dental supply houses in sheet form. It is considerably used for trial base-plates, and formerly was much used for taking impressions. Its use for this purpose has been, of late years, superseded by modelling compound, a superior material.

Plaster of Paris.[1]—Plaster of Paris is made from the mineral called *gypsum*. This mineral is found in various forms, as *massive* or *rock* gypsum; *alabaster*, a pure white, fine-grained massive gypsum; and *selenite*, a crystalline, almost transparent gypsum. The chemical composition of pure gypsum is $CaSO_4 + 2H_2O$. Therefore, pure gypsum is a hydrous sulphate of lime, made up of one molecule of calcium sulphate combined with two molecules of water. This, when reduced to percentages of weight, corresponds to the following:

$$\text{Gypsum } (CaSO_4 + 2H_2O) = \begin{cases} \text{Lime sulphate } (CaSO_4) & 79.1 \text{ per cent.} \\ \text{Water } (H_2O) & 20.9 \text{ per cent.} \end{cases}$$

$$\text{Lime sulphate} = \begin{cases} \text{Lime } (CaO) \\ \text{Sulphur trioxide } (SO_3) \end{cases}$$

Gypsum is rarely found chemically pure. The usual impurities are silica, alumina, iron oxide, calcium carbonate, and magnesium carbonate. Usually these impurities do not attain a volume of 3 per cent., and are often less than 1 per cent. Gypsum is prepared for the market by grinding and burning, and mixing with accelerators and retarders. The products of manufacture are designed for a definite purpose, and cannot be interchanged advantageously. The dentist should have a general knowledge of the various gypsum products, so as to select his plasters intelligently.

Classification of Plaster.—"*A*. Produced by incomplete dehydration of gypsum, the calcining being carried on at a temperature not exceeding 400° F.

"1. Produced by the calcining of a pure gypsum, no foreign material being added either during or after calcining. *Plaster of Paris.*

[1] The authorities for this general sketch of plaster of Paris are: Cements and Plasters, by Edwin C. Eckel, C.E., published by John Wiley & Sons, New York, 1907; Calcareous Cements, by Gilbert R. Redgrave and Charles Spackman, published by Charles Griffin & Co., London, 1905.

"2. Produced by the calcining of a gypsum containing certain natural impurities, or by the addition to a calcined pure gypsum of certain materials which serve to retard the set of the product. *Cement plaster.*

"*B.* Produced by the complete dehydration of gypsum, the calcination being carried on at a temperature exceeding 400° F.

"3. Produced by the calcination of a pure gypsum. *Flooring plaster.*

"4. Produced by the calcination, at a red heat or over, of gypsum to which certain substances (usually alum or borax) have been added. *Hard-finish plaster.*"

In the trade these names are used extensively, but at times in a careless and indefinite fashion. *Calcined plaster* commonly means a burned plaster to which no retarder has been added. It may be either *plaster of Paris* or *cement plaster. Stucco plaster* is less finely ground than plaster of Paris, and usually is not made of as pure a quality of gypsum. *Wall plasters* are made by adding not only a retarder, but some kind of fiber to calcined plaster. Keene's, Martin's, and Mack's cements are *hard-finish plasters* variously treated with such substances as alum, borax, borax and cream of tartar, potassium carbonate, and potassium or sodium sulphate.

Chemistry of Gypsum Burning.—If pure crude gypsum is heated to a temperature of more than 212° F. and less than 400° F., a certain definite portion of the water of crystallization will be driven off, and the gypsum thus partially dehydrated will be plaster of Paris. Plaster of Paris has the formula $CaSO_4 + \frac{1}{2}H_2O$, which equals calcium sulphate ($CaSO_4$), 93.8 per cent., and water (H_2O), 6.2 per cent. Dehydration to this extent can be accomplished at any temperature between 212° F. and 400° F., but for economy of fuel and time it is usually carried on at the highest allowable temperature; and 330° to 395° may be regarded as the usual limiting temperature for plaster manufacture. The highest grade dental plaster is calcined at about 261° F. About 400° F. is a critical temperature, for if gypsum be heated much above this it loses *all* of its water of crystallization, becoming an

anhydrous sulphate of lime, and useless as a normal plaster. Under certain conditions, however, "dead-burned" gypsum gains certain properties, and forms flooring and hard-finish plasters. Partially dehydrated gypsum has the property of taking up the lost water of crystallization and setting or recrystallizing. If the gypsum is pure and unmixed with retarder, the setting of the plaster will be complete in a few moments, while dead-burned plaster, as such, is spoken of as non-setting; however, it does set, but requires hours for the initial set and weeks for complete hydration.

There are three methods of calcining gypsum, known as the kettle, oven, and rotary cylinder processes. Formerly the kettle process was most used in America, while the oven and kiln process was largely in vogue in England. The rotary cylinder process is an improved method of recent years.

Grinding of Gypsum Products.—Grinding is an important factor in the manufacture of gypsum products. In the kettle process the rock is first ground and then roasted, while in the oven and the rotary cylinder processes the rock is broken into convenient size masses, roasted, and then ground. The use for which the plaster is designed will determine its fineness. The finest ground plaster only is suitable for impressions and most dental work. Eckels states that: "A dust chamber located above the rotary calciner catches the most finely ground plaster, which is marketed for dental plaster and other special purposes."

The Theory for the Setting of Plaster.—M. Le Chatelier has formulated a new theory, based upon the phenomena of supersaturation investigated by Marignac. This observer has shown that the "Hydrated calcium sulphate with half an equivalent of water, which remains undecomposed at a temperature of about 310° F., dissolves freely when shaken up with water, but that after a short interval the solution becomes turbid. This is due to the formation of a crystalline precipitate of the common hydrate with two equivalents of water, which has the formula of gypsum. The solution formed in the first case is five times as concentrated as that

made from the less completely hydrated sulphate. It would appear from this that the most important agent in the accomplishment of the setting process is the relatively soluble hydrate, namely, that with a small percentage of water. This hydrate is at once dissolved, and then gives rise to the formation of the other hydrate, with the full equivalent of water. The latter compound decreases the solubility of the mixture, and the water becomes supersaturated with the $CaSO_4 2H_2O$ hydrate, which crystallizes out. This process continues so long as there remains any of the soluble hydrate $[2(CaSO_4)H_2O]$ to fortify the solution.

"The set of plaster is thus the result of two distinct series of operations, which take place simultaneously: First the particles of calcium sulphate in the act of hydration are dissolved in the water used to gauge them, and produce a supersaturated solution; the solution thus formed deposits crystals of the hydrate sulphate. These crystals gradually increase in size, and form a compact mass in the same way as do all similar crystals deposited slowly from a saline solution, and this process is continued as long as any of the more anhydrous sulphate remains available to become dissolved and to keep the solution supersaturated."

The Expansion, Contraction, and Compressibility.—These are three properties of matter, of which little has been determined for dental plaster of Paris. However, in general terms, it may be stated that dental plaster first expands and then contracts. The expansion is influenced by the composition of the brand of plaster, also by the manner of manipulation, hence the stress that is placed upon the brand and method of manipulation in this book. All plasters are subject to eventual contraction. Several men have, in a crude way, demonstrated the expansion and contraction in dental plaster, and Prof. Prothero has made some scientific investigation along this line; but not enough to arrive at a definite conclusion. Practice has demonstrated the truth of the theory that dental plaster of Paris should be combined with a definite quantity of water and the crystallizing process interfered with as little as possible.

Compressibility.—Attention has but recently been called to this property. The term is indifferently used by various writers. Writers on calcareous materials for the building trades use compression as synonymous with crushing, while in dental literature it refers only to their condensation in confinement, not to breaking of the unconfined material under pressure. This property of the calcareous materials accounts for most of the warping of vulcanite dentures, and is considered in Chapter VI.

IMPRESSION TRAYS

Definition.—A dentist's tray or cup used for holding the impression material while taking an impression of the mouth or teeth. Tray is the better term to use, as it conveys an idea of a utensil having flanges and a capacity to hold and carry, while cup conveys the idea of symmetry of form with a base on which to stand, and holding capacity. Trays are made of various materials and sizes.

Tray Material.—The materials of which trays are made are block tin or alloyed tin, cast and pressed aluminum, German silver, and porcelain. Each material has its advantages and disadvantages, and for special purposes the tray should be constructed of the materials best adapted. While porcelain is the most cleanly material, it is not practical because its form cannot be changed, and it is easily broken. Block tin (or some of its alloys) is most commonly used. The trays made of this material may be readily changed in form, by cutting and bending, which is an essential property.

Tray Nomenclature.—A tray has a *body* and a *handle*. The body consists of a *floor* and *flanges*, and those designed for the upper jaw have a *vault portion*. There are two types of floors—*oval*, for edentulous jaws, and *flat*, for accommodating remaining teeth. The flanges are called *outer* and *inner*. The outer flange has two portions, the anterior or labial, and the posterior or buccal. The dividing line is the proximity of the distal surface of the cuspid tooth. The inner

flange is also called the lingual flange. The surfaces of the tray are named for the surfaces they approximate, as maxillary, labial, buccal, and lingual. (These terms are used also in base-plate nomenclature.) The term palatal surface is used indiscriminately, meaning either the maxillary or lingual surface. The term is confusing, and should be avoided.

The vault portion spans the space described by the curve of the lingual flange of the upper tray.

The handle is an extension from the union of the floor and the anterior flange. The handle is designed to be used while carrying the tray into the mouth; also for removing the tray and impression from the mouth. The handle should never be used for holding the tray while the impression is hardening, as it acts as a lever, and it is almost impossible to avoid enlarging the intaglio of the impression.

FIG. 17

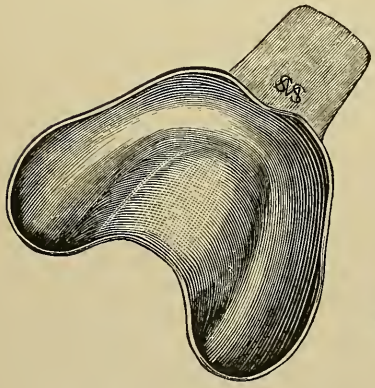
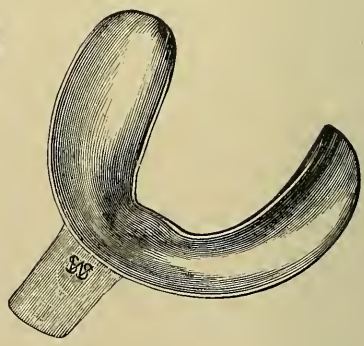


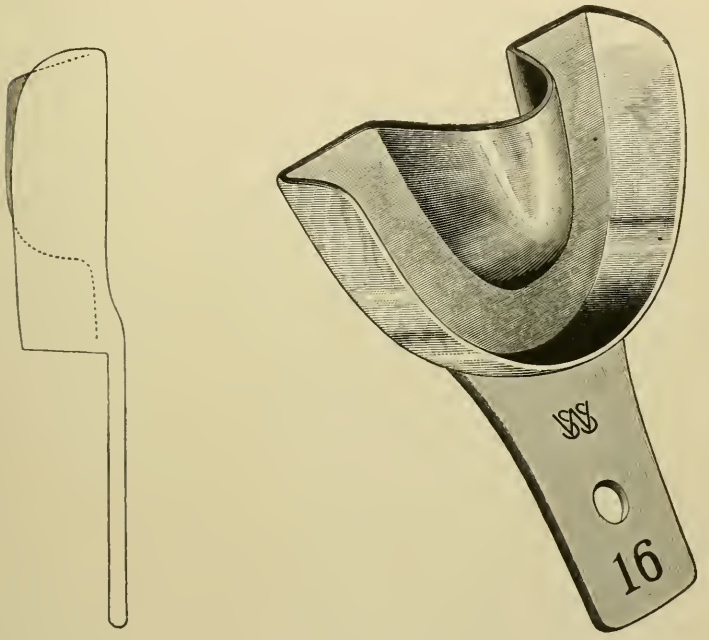
FIG. 18



Tray Forms.—The form of the tray should be such as to approximate the form of the part of which the impression is to be taken. This would require a great variety of trays, therefore it is desirable to have the trays constructed of a material that can be readily adapted to the individual case. These changes are made by cutting away the undesired portion, or by bending in or out the portion not properly

adjusted; or the desired form may be obtained by adding some plastic adhesive material, such as wax or modelling compound. This added material should not be considered as a part of the impression, but as a part of the tray only as the surface outline of the built-up tray would be such as a specially constructed one should have. In fact, some

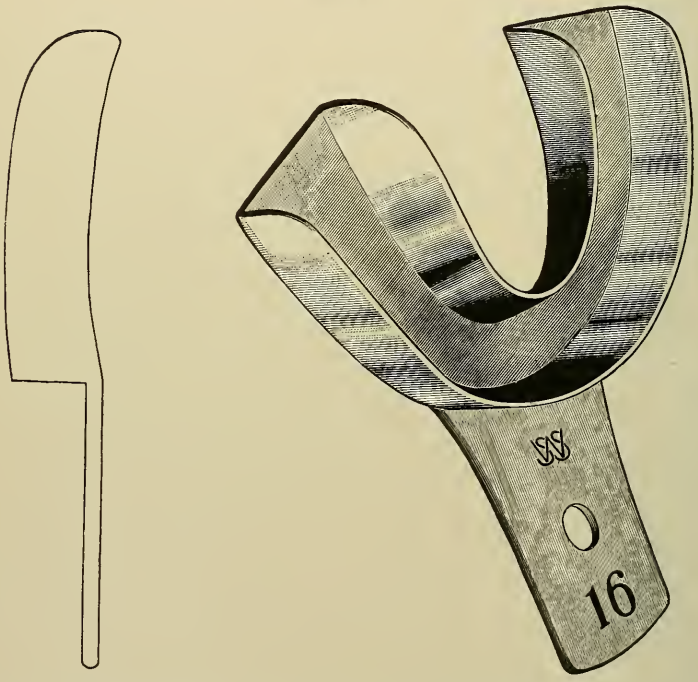
FIG. 19



prosthetists have advocated taking a crude impression and making a plaster cast from which a tray is constructed. (Dr. Bean's method, Turner's *American Text-book*.) This tray would have the advantages of requiring but a small amount of impression material, and of carrying it accurately into place. Such methods require too much time and work, and do not meet the requirements of really diffi-

cult cases. The metal tray should approach equally all the surfaces to be impressed. There should be a space of about one-eighth of an inch to be occupied by the impression material. This will give sufficient body of material for strength, and in case of fracture of the impression, the pieces are thick enough to be readjusted. The exception to

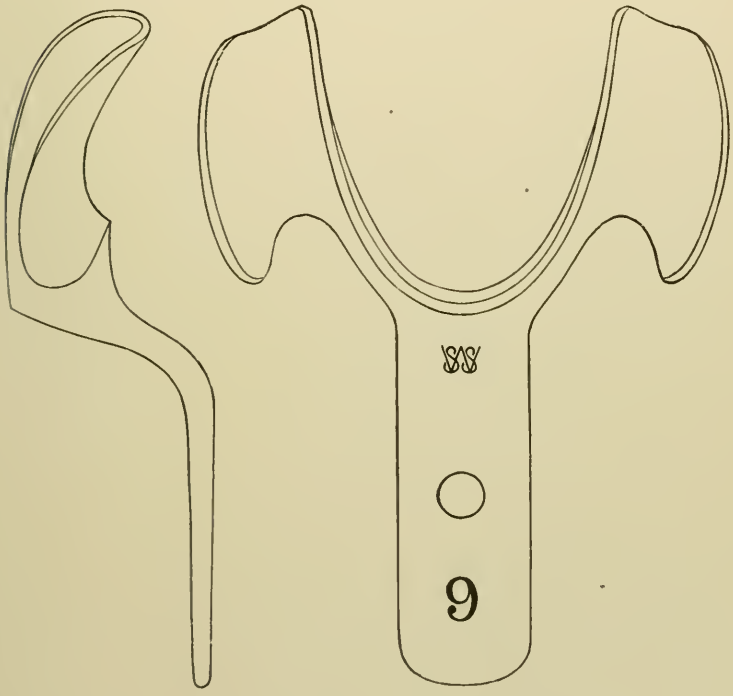
Fig. 20



the one-eighth-inch rule is where compression of the soft tissues is required. In such cases no stock tray could answer the purpose; but a simple stock tray may be reënforced so as to perfectly meet the requirement. It is wise to reject all fanciful and complicated trays, depending entirely upon the simplest forms. The various forms of stock trays are made

in several sizes. The student or young practitioner should select a few sizes of each of the primary forms, and, as necessity, requires extra sizes, special forms and duplicates may be added to the equipment. The several manufacturers offer similar lines of trays, and each may have some special and fanciful forms, but these should not interest the student.

Fig. 21



For the purpose of illustration, the well-known S. S. W. trays have been selected. These are made of the best quality of Britannia metal, and will meet all ordinary requirements. Fig. 17 shows an upper tray of the oval floor type. There are eight sizes of this type, numbered

from 1 (largest) to 8 (smallest). For the first outfit sizes 2, 4, and 6 will suffice. Fig. 18 illustrates the lower trays of this type. There are seven sizes, of which 1, 3, and 7 are good selections. Fig. 19 represents the flat floor type. There are five sizes for the upper jaw, numbered from 12 to 16. Nos. 12 and 15 should be the first selection. Fig. 20

FIG. 22

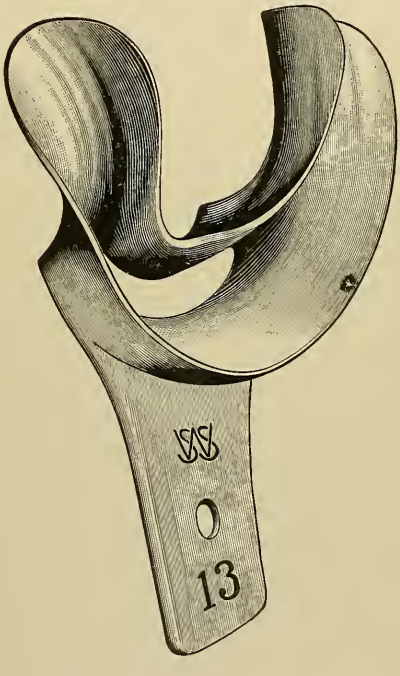
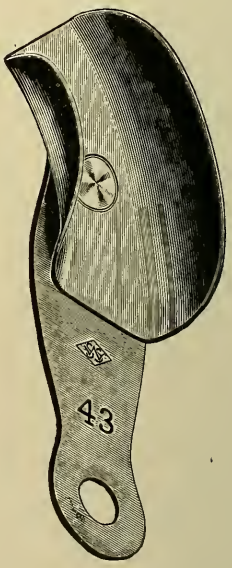


FIG. 23



shows a lower tray of the flat-floor type. The largest and smallest of the sizes, 14 and 16, will well complete the initial collection of trays. While the prosthetist can adapt the ten trays recommended to meet every requirement that may be present, it is well to have some special trays. The most desirable of these are shown in Figs. 21, 22, and 23. The

first two are designed for the lower jaw only, while the last one, because of its swivel joint, may be used in any part of the mouth for any small impression.

TECHNIQUE FOR FULL UPPER IMPRESSIONS

Classification

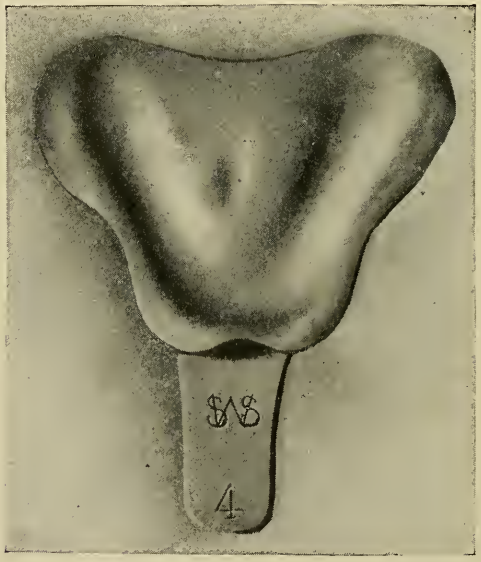
- Normal.
- High vault.
- Flat vaults
  - Thin and tense tissues.
  - Medium soft tissues.
  - Soft and flabby tissues, ropy secretions.
- Enlarged raphé.

Application.—We will suppose we have an edentulous patient in the chair. The patient's comfort having been looked after by adjusting the chair, placing suitable protection for the clothing, and with a glass of water upon the bracket table; the examination of the mouth having been made as described in Chapter I, the case being a "normal" one in every respect, will indicate that plaster impressions are required. The case being of average size will require the oval floor tray No. 4. The tray should be tried in the mouth to ascertain if any alteration is required. As the aperture of the mouth is less than the width of the palatal end of the tray, it will require suitable manipulation for its insertion. This is accomplished by the operator standing erect, at the right and a little back of the patient; the patient's chin should be about on a level with the elbow when the chair and patient's head are each slightly tilted backward. The patient is instructed to open the mouth moderately wide, when the tip of the index finger of the left hand is placed in the left angle of the mouth. The tray is grasped by its handle between the thumb and first two fingers of the right hand. The anterior portion of the right buccal flange of the tray is placed in the right angle of the mouth, and while distending the lips the tray is swung into

the oral cavity. The palatal border of the tray is carried upward over the tuberosities, at the same time the anterior portion of the tray should be depressed sufficiently to permit a view of the relation of the palatal border of the tray with the tuberosities and vault.

Adjusting the Tray.—Should the flanges be too close to the tuberosities, they may be bent outward by grasping the body of the tray in the left hand, and the use of a pair of 4- or 5-

Fig. 24



inch smooth-nosed plyers in the right hand. By the same means the flanges may be brought nearer to the tuberosities. Should the vault portion impinge, it may be depressed by striking a few times with a horn mallet. (See Metal Plate-work Implements, Chapter XI.)

Fig. 24 exhibits a tray with an extreme amount of bending of the flanges outward, and the vault portion slightly de-

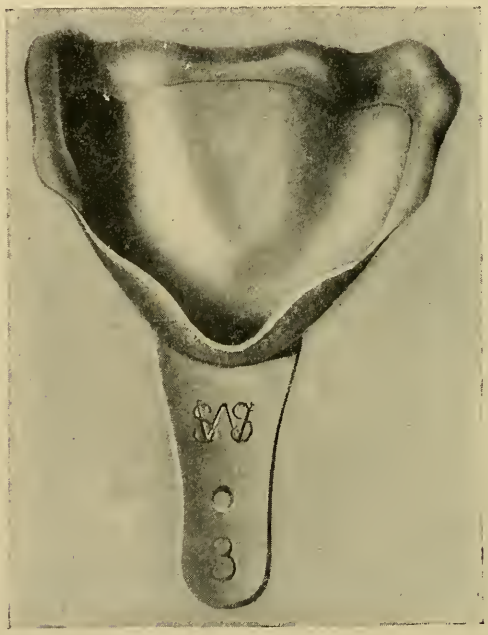
pressed. In very flat mouths the base-plane may be very broad, when it would be desirable to have the flanges bent outward rather than cut away.

The anterior flange should next be inspected. Should the tray impinge upon the frenum labii, relief should be afforded by deepening the notch in the tray by use of a half-round file, such as is used in vulcanite work. The flange at either side of the median notch may require adjusting, and often should be cut away. This flange should not obstruct free manipulation of the impression material. It would be advantageous if this portion of all prosthetic trays were largely cut away. The student should keep this axiom in mind, that it is better to have the flanges cut away too much rather than not enough, for they may be easily reënforced.

Reënforcing the Tray.—This may be done with either wax or modelling compound. The writer much prefers pure yellow beeswax. This is done by softening a strip of wax by the dry heat method and making it into a roll a little larger than the shaft of a lead pencil. The palatal border of the tray is slightly warmed in the flame and the roll of soft wax is formed upon the maxillary surface, permitting the ends of the wax roll to extend around the tuberosities. This is placed in the mouth and forced firmly to place. The tray is then removed from the mouth, the wax made cold, and any excess removed with a hot wax spatula or knife. As has been stated, this reënforcement of wax is in no sense a part of the impression, it should be considered only as an integral part of the tray. This peripheral reënforcement serves a double purpose: first, it acts as a dam to prevent the soft plaster extending too far backward, and second, it acts as a compress to prevent the contraction of the palate muscles drawing down or depressing the palatal portion of the impression. Inattention to this portion of the impression often causes failure in the retention of the denture. Fig. 25. illustrates the tray with wax reënforcement of the palatal border. The reënforcement may extend forward upon the buccal flanges to include the malar processes, but it should not extend so far forward as to include the buccal frena

However, if the reënforcement extends over the malar process it should be properly adjusted. This is done as follows: When the tray with the peripheral roll has been forced into place, the tray is supported by firm pressure of the index finger of the left hand placed upon the centre of the lingual surface of the vault of the tray; when the right

Fig 25



cheek is grasped and drawn downward by the index finger and thumb of the right hand, the cheek is released and instantly pressure is made with the fingers upon the cheek over the wax. The left index finger is replaced with the right one, when the left cheek is manipulated in like manner. This illustration shows also the frenal notch sufficiently cut away to prevent impingement, and the labial flange properly adjusted. The

tray is now prepared for the case in hand, and could not be improved upon even if a new metal tray were to be made for this individual case.

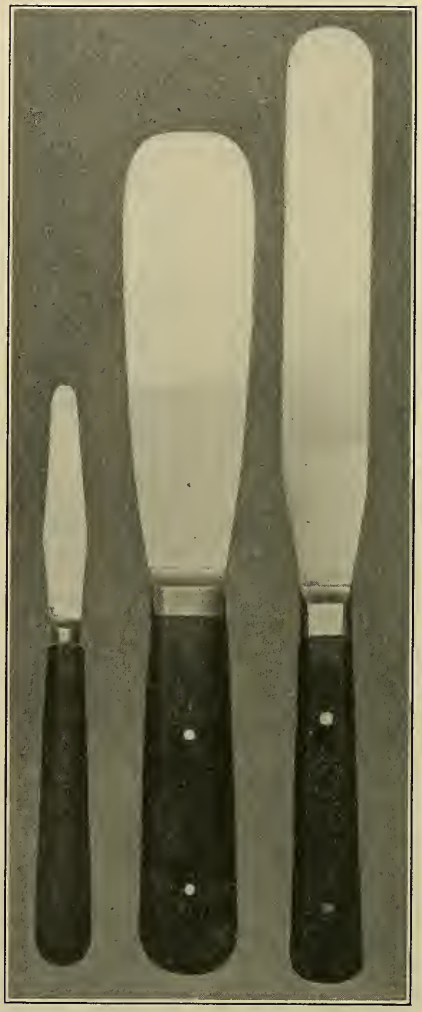
Changing the Position of the Patient.—The tray being properly prepared for the impression, it is well to change the position of the patient to an upright position with the head slightly inclined forward. This is simply a precaution to prevent any plaster falling into the throat. However, an experienced operator may keep the patient in the first position for his own convenience, and be justified in so doing because of his expertness; but not so with the inexperienced operator.

Mixing the Plaster.—One fluidounce of water, of the temperature of the room or a little warmer, is placed in a rubber bowl (Fig. 26) and four or five grains of salt (NaCl) dissolved

FIG. 26

in it. A measure holding 2 fluidounces should be filled with regular dental plaster (French's), but not packed; this plaster should be shaken or sifted into the salted water and gently agitated with the plaster spatula (Fig. 27) until it is smoothly mixed. The object desired is to get the plaster cement smoothly mixed, free from confined air, and in the mouth as quickly as possible. The time required should be but a few seconds. If a special impression plaster is used in place of French's regular dental plaster, the salt will probably not need to be added, as no doubt the manufacturer

Fig 27



has added an accelerator. Some operators prefer the use of potassium sulphate (K_2SO_4) in place of common table salt (NaCl), but either serves an excellent purpose, the NaCl having the more agreeable flavor.

Filling the Tray.—The mixed plaster should be transferred from the bowl to the prepared tray as expeditiously as possible. The plaster should cover the entire maxillary surface of the tray, it should be flush with the palatal reënforcement and piled up somewhat at the anterior vault portion.

Inserting and Placing the Filled Tray.—The filled tray should be instantly inserted into the oral cavity, using the technique previously described in this chapter. While the thumb and index finger support the tray, the second finger should be carried backward against the vault of the tray. This will favor carrying the palatal border of the tray firmly into place. While placing the palatal border of the tray the index finger of the left hand is slipped forward under the lip, which is grasped between the finger and thumb, and the lip distended. As the palatal border of the tray is held securely in position, the anterior portion of the tray is carried into place by a swinging upward movement of the hand. Instantly the median portion of the lip, which is in the grasp of the finger and thumb of the left hand, should be drawn downward, thus settling the frenum labii in the soft plaster. The finger is then slipped backward to the left angle of the mouth, which is grasped and drawn downward, marking and placing the buccal frenum. Either the first or second, or both of these fingers of the left hand are placed against the vault of the tray, thus releasing the right hand. The right angle of the mouth is now drawn downward, thus placing the right buccal frenum. While firm pressure is maintained upon the vault of the tray, the *cheeks and lip are firmly pressed against the soft plaster with the thumb and fingers of the right hand.* By this means the soft tissues of the buccal and labial walls of the maxillæ are compressed. No effort need be made to compress the plaster over the malar processes, as the wax reënforcement will provide for this. Furthermore, if

there is any portion of the periphery of the plate that should not press firmly, it is that over the malar processes. The fingers of the right hand may now relieve the left hand, which is placed upon the top of the patient's head. By pressing with both hands, not hard but firmly, the setting plaster is held more steadily in place. If the operator removes a little of the excess plaster upon a finger of the left hand as he removes it from the mouth the last time, he will have a guide as to the hardening of the plaster. It should be left in the mouth (probably two or three minutes) until it will break with a clean fracture, when it is ready to be removed.

Removing the Impression.—When the plaster breaks with a clean fracture and does not crush, the impression should be removed by grasping the handle of the tray with the thumb and fingers of the right hand, while the left cheek is elevated from within with the index finger of the left hand. Pressure is made upon the handle in such a manner as to depress the palatal border of the impression. If the impression does not loosen after a reasonable amount of force has been applied in this manner, a slight rocking movement of the handle up and down may aid. If the operator has left the impression too long in the mouth it may be necessary to throw a jet of water, with a water syringe, around the periphery of the impression. This is done by tilting the head slightly backward and lifting the lip and cheek upon one side, when the crevice between the impression and the lifted soft tissues is filled with water. The other side of the mouth is treated in the same manner, when the handle should again be manipulated. If the impression is removed at the proper time there will be only moderate adhesion. Strong adhesion of a plaster impression is no evidence that it is a good one, but it is a positive evidence that the plaster has been left so long in the mouth that it has absorbed all the moisture from the surface of the mucous membrane, thus creating a powerful vacuum suction, which upon being broken may tear the mucous membrane. With attention given to the work in hand there should be no excuse for such an accident.

Fig. 28 shows the maxillary surface of a plaster impression. Notice the peripheral outline. Fig. 29 shows the palatal

Fig. 28

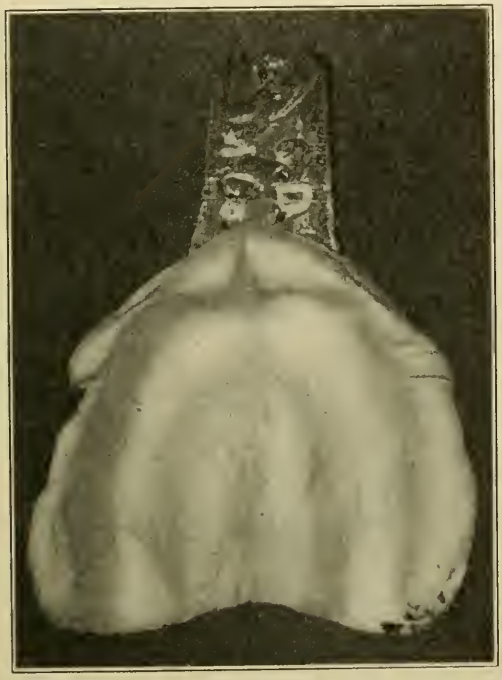
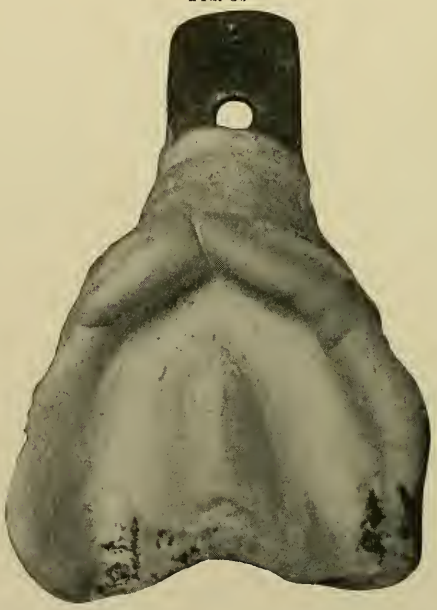


Fig. 29

border of the impression. Notice the clean cut-off of the plaster by the wax reënforcement. Fig. 30 is another plaster impression in which the palatal border reënforcement wax has entirely excluded the plaster in places, as can be seen by the difference in color. This illustration shows also the excess plaster pressed forward upon the handle of the tray. The edge of the anterior flange of the tray can be seen much below the periphery of the impression, and yet

FIG. 30



there is much thickness to the labial wall of plaster. This is because the low labial wall of the tray was reënforced with wax, which with the soft plaster was forced against the labia wall of the maxillæ by the external pressure upon the lip. In contrast with this, Fig. 28 shows a thin labial wall of plaster, because a higher anterior flange was used with no wax reënforcement. Fig. 31 shows a tray with palatal and

labial wax reënforcements ready to receive the freshly mixed plaster.

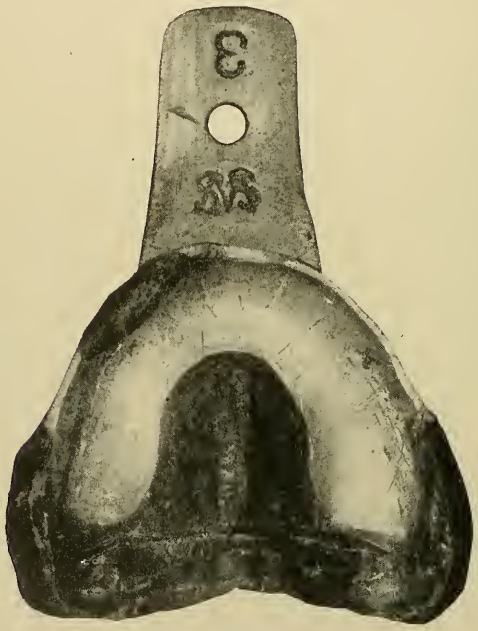
The method detailed will suffice for a very large percentage of cases requiring a full upper artificial denture; but there are some cases that will require special manipulation in order to produce the best results. These may be classified as: (1) High vaults, (2) flat vaults, and (3) enlarged raphé.

Fig. 31

High Vaults.—The high vault may be oval, square, or an inverted V-shape. In either case the wax reënforcement should not only be placed along the palatal border, but it should be carried forward to fill the entire vault. After the wax has cooled, the surface of the anterior portion to the thickness of $\frac{1}{16}$ of an inch should be removed with a warmed wax knife. The palatal border should be left undis-

turbed to the width of $\frac{1}{4}$ to $\frac{3}{8}$ of an inch. The object of the reënforced vault portion is to insure the plaster being carried fully to place, and the use of less plaster. Fig. 32 shows a tray prepared for an inverted V vault. A high vault will always require a high labial flange to the tray. It is better to use a tray with a narrow labial flange, and then build the

Fig. 32



required flange of wax, thus providing for the compression of the soft tissues over the labial wall of the maxillæ. The illustration shows the low metal flange upon the right side and the wax restoration upon the left.

Flat Vaults.—These cases will present one of three conditions of the soft tissues: (1) Thin and tense; (2) medium soft; or (3) soft and flabby. Fig. 33 is a cast of the second class.

The impression from which this cast was made was taken in the tray shown in Fig. 24. Obviously a case of this kind would require that the flanges of the tray should be cut away or that they should be bent well over, as shown. The latter is to be preferred, as it provides the desired large base plane. (This feature will be further considered under the subject Retention of Artificial Dentures.) In both the first and second classes the impression is taken in the usual manner. It is in these flat cases that the student is tempted to omit the palatal border wax reënforcement, but he should remember that the rule is universal, and has no exceptions, that to omit this reënforcement in any case is to invite failure;

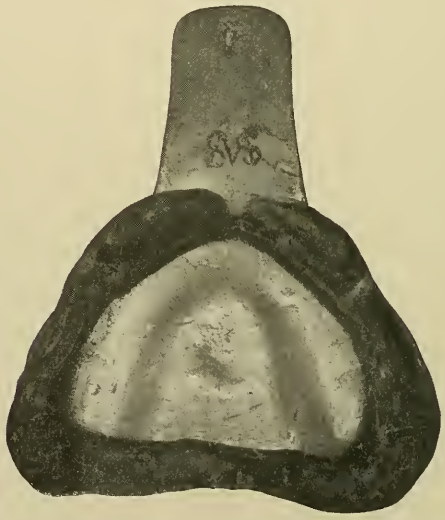
FIG. 33

however, failure may not come at the bidding. The third class of flat vaults requires special consideration and treatment.

Difficult Flat Vaults.—The flat vault *per se* is not necessarily difficult to cope with, for under favorable conditions it provides the strongest retention. However, there are such a considerable number of vexatious cases associated with flat vaults that they have become the *bête noire* of the dental profession. This is a very unjust condemnation, because there are other vault forms that present much greater difficulties. The trouble is that the dentist fails to recognize the conditions, therefore fails to meet the require-

ments. In the three classes named of conditions of the soft tissues, the first class (hard and tense) presents only the usual difficulties of impression taking; yet the retention in this class is poor. This will be considered in the chapter on Retention. The second class (medium soft tissues), provided the fluids are normal, is one of the most favorable cases the dentist can have. The third class (soft and flabby) are troublesome and require study, and suitably taken impressions.

FIG. 34



Before entering upon the technique of taking impressions for this class, it is necessary to refer to another factor sometimes associated with flat vaults. A thick ropy secretion is always a menace to the retention of artificial dentures. This factor is mentioned at this time because one method of impression taking is especially designed to offset the viscid secretions. In this third class the flabby tissue may be evenly distributed over the entire surface to be covered with the base-plate, or it may be interspersed with hard tissue. Each condition will require a suitable impression.

Technique for Flabby Gum.—When the soft tissues are thick and evenly laid over the surface to be covered with the base-plate, a suitable size flat oval floor tray is selected, a roll of soft wax, the size of a lead pencil, is placed upon the maxillary surface at the periphery of the tray, carried into the mouth, and pressed firmly into place. While holding the tray firmly with a finger or two upon the centre of the vault of the tray, the lip and cheeks are drawn downward and then externally pressed inward. The tray is then removed from the mouth, and the wax cooled. The space formed by the peripheral wax is filled with a soft mix of plaster. The technique of inserting the tray into the oral cavity, and adjusting it is the same as previously described. The object sought is to have the soft tissues evenly compressed throughout the entire periphery of the base-plate and no compression over the enclosed portion. Fig. 34 shows a flat tray with peripheral wax.

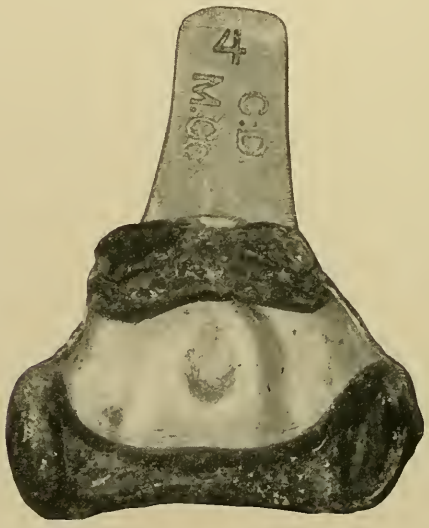
Technique for Interspersed Hard and Soft Tissues.—As an axiom, it may be stated that increased pressure should not be placed upon either hard or soft tissue in the vault of the mouth except upon the palatal border; or, conversely stated, increased pressure should be made upon the palatal border, the alveolar ridge, and external to the alveolar ridge. The most common occurrence of the condition under consideration is a spongy vault with the alveolar ridge moderately hard upon either side as far forward as the location of the cuspids, and a flabby condition from cuspid to cuspid location.

Fig. 35 is a tray reënforced for such a case. The palatal border wax should extend forward to rest upon the malar process, only when it is covered with an excessive amount of soft tissue. The anterior portion of the tray should have a sufficient quantity of wax to cover all of the flabby gum tissue. The metal flange should be cut low and replaced with a thin piece of yellow wax. As in all cases, the soft wax is adjusted to the mouth. The tray is filled (avoid much excess) with moderately thin plaster, inserted, and adjusted as previously described. Notice! Hard (not firm) but hard-continued pressure is made upon the centre of the vault of

the tray. The lip and cheeks are drawn downward and compressed externally as in other cases. The pressure upon the tray is continued until the plaster has set. By this means a firm foundation will be established for the artificial denture.

Rarely will the buccal portion of the gum tissue be excessively flabby, but when it is it must be compressed; and the buccal flange of the base-plate must extend as far outward

Fig. 35



as the free action of the buccinator muscle will permit. The object sought is to have the force of mastication distributed over as broad a surface as possible, and thus prevent undue pressure upon the palatal processes of the maxillæ.

So far there has been discussed but one method, with its modifications, for taking full upper impressions. The retention principle underlying this method is, "Uniform pressure and absolute contact." This principle is more scientific and less subject to adverse criticism than the remaining one

(atmospheric pressure) for retaining full upper artificial dentures. Plaster of Paris with a suitably prepared tray is the best material the dental profession of today possesses to meet the requirements of the cases so far detailed. The one serious objection to plaster of Paris is that there is no practical test for the perfection of the impression. Dependence must be placed upon knowledge and skill; knowledge of the requirements of the case and skill in applying the knowledge. Should a plaster impression be replaced in the mouth, strong adhesion may be induced by its capacity to absorb the mositure upon the mucous membrane; but this will take place equally as well or better with a poorly adapted impression. An inspection of the impression may show a perfect imprint of the mucous membrane, but it does not differentiate between proper compression and improper distortion of the soft tissues. So knowledge and applied knowledge (skill) must be arbiters of the perfection of the impression. The artificial denture made from an impression may be positive evidence that the impression was perfect, but it is no evidence that it was not good.

Mention has been made of ropy or viscid secretions as an adverse factor associated with flat and more or less flabby vaults. The author is of the opinion that these conditions may be best met by the use of modelling compound. Also, he believes that no first impression should be taken with this material, because the line of demarcation where plaster ceases to be the best material and modelling compound demanded is so obscure that preference should always be given plaster of Paris. Modelling compound is far more difficult to handle (properly) than plaster of Paris. The latter material is more scientific and requires less skill than the former, especially if the case is a difficult one. This last statement is contrary to the generally accepted opinion, but nevertheless it is true. The reasons for these statements will develop as the methods for the use of the compound are described.

MODELLING COMPOUND FOR FULL UPPER IMPRESSIONS

As Ordinarily Used.—A tray is selected, and the flanges adjusted as for a plaster impression. No reënforcement is required. A portion or a whole cake of modelling compound, as the judgment dictates, is softened in water (see page 58) and placed in the warmed tray. In manipulating the compound all folds should be kept on the under portion, so the surface taking the imprint may be smooth and continuous. The side of the index finger may be embedded first upon one side and then upon the other, so as to form a groove for the alveolar process. The surface is then given an extra softening by passing over a smokeless flame. The compound filled tray is carried into the mouth and forced into place after the manner described for plaster (page 69). The lip and cheeks are manipulated in the same manner as for plaster. The compound is left in the mouth until it has hardened. Hardening may be expedited by using cold water. A small piece of cloth (an aseptic napkin) is saturated with cold water and held against the lingual surface of the tray. Some of the cold water may be thrown under the lip with a syringe. When the compound has become hard it is removed in the same manner as a plaster impression, except in no case will it be necessary to use a spray of water as an aid to loosen it.

Advantages and Disadvantages.—The advantages of compound are claimed to be that it takes a sharp impression, does not break upon removal, and compresses the soft tissues. The first two claims are true, but the second claim of superiority should be classed as a disadvantage, for a material that does not break must bend or drag when taken from an undercut or dovetail-shaped space. The third advantage claimed is very questionable. As ordinarily used the compression is not under the control of the operator. The material is usually forced so far backward upon the soft palate as to produce contraction of that organ, and cause

depression in place of compression at the palatal border of the impression. The soft tissues upon the labial and buccal surfaces are usually distorted. Because of this distortion many operators find it expedient and useful to use a "bead" upon the maxillary surface of labial and buccal flanges of an artificial denture. Following a properly taken impression, a bead in this position should be unbearable. One skilled in the use of any material may produce excellent results, but that is not evidence that it is scientific or the best. The confusion existing in the profession regarding the various impression materials is due to a lack of comprehension of the underlying principles.

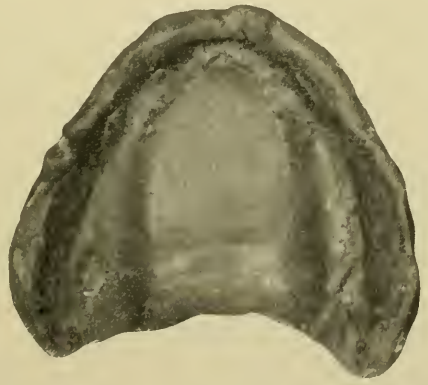
Where and How to Use Modelling Compound.—It has been stated that ropy and excessive secretions of the mouth are adverse conditions for retaining artificial dentures. The method of offsetting these untoward conditions will depend upon the associated factors. If they are accompanied by a flat vault and flabby soft tissues they can probably be best obviated by this method of taking the impression. The author believes this is the one place in which a modelling compound impression is indicated. However, the usual method just described will in no wise meet the requirement. The principle involved in this special impression is *compressive bearings with a large vacuum cavity and vent spaces.*

Technique.—A suitable size oval floor tray having been selected, the handle and most of the labial and buccal flanges are cut away (Fig. 35). If an unsatisfactory base-plate has been constructed it may be converted into an admirable tray by cutting away at least one-half of the width of the flanges. About one-third of a cake of compound is softened, dried, and spread over the warmed maxillary surface of the prepared tray. This is carried into the mouth and hard continued pressure applied so as to compress all the tissues over the vault and ridges; at the same time the patient should comply with the instruction previously given and draw the lip and cheeks downward by hard vigorous muscular action. This, Dr. J. W. Greene, in the Greene brothers' method of

impression, calls muscle trimming. The best position in which the operator may stand while taking this form of impression is directly back of the patient. The partially taken impression is removed from the mouth, thoroughly chilled, and any excess removed. The peripheral labial and buccal borders are warmed over a small, weak Bunsen flame and quickly returned to place in the mouth. It is securely held in place with one hand, and, while the patient is muscle trimming, the operator makes interrupted compression over the lip and cheeks with the disengaged hand. It may be necessary to re-warm and muscle trim several times, or an addition of soft dry compound may be needed upon portions of the rim of the impression. This addition may be made by "tracing on" with a stick of compound. When the operator is satisfied that the rim of the impression is perfectly adapted backward to the anterior border of the malar processes, the impression is thoroughly chilled, dried, and a small roll of soft modelling compound placed along the palatal border, upon the maxillary surface, and extended around the tuberosities to the malar processes. This addition is made quite soft in the small Bunsen flame, carried into the mouth, and quickly forced into place, removed, and dried. If it has not been sufficiently compressed, it is again softened and pressed in the mouth. The impression may now be considered complete. It is placed in cold water until thoroughly cold, and without drying it is replaced in the mouth and very firm pressure made upon the lingual surface of the tray while the lip and cheeks are lifted and drawn into position over the rim of the impression. The fingers are removed from the mouth and the patient requested to remove the impression. If the impression has been properly manipulated it may be impossible for an inexperienced patient to remove it. The patient should be instructed to dislodge it by working the lip and cheeks and closing their lower teeth upon it in every way possible. Should it prove to be insecure at any place it should be corrected, either by softening and muscle trimming, or by adding soft compound.

Rationale.—The reason for this excessively strong adhesion is apparent. By this method of taking the impression there is absolute contact of the entire periphery of the impression except over the malar processes, where there is an automatic valve in the soft tissues of the cheek. As the peripheral border is forced into the soft tissues and either cheek raised, the moisture and air occupying the free space within the impression is forced out over the malar process; then, as the cheek is lowered, it acts as a valve and prevents ingress of air. As the pressure is relieved from the lingual surface of the tray, the resilience of the soft tissues under the periphery of the impression causes a thin vacuum space over nearly the whole maxillary surface.[1]

FIG. 36



This explanation of the strong retention of the impression suggests also how to remove the impression, which is done by raising the cheek and pulling downward upon the periphery of the impression at the malar process. As air is admitted the impression is loosened.

It should be apparent that this method applied to thin tense tissues either would not produce adhesion or would soon become exceedingly painful.

[1] This description is but a slight modification of the Greene brothers' method.

The durability of such strong adhesion and its sequence are not relevant at this time, but will be discussed in the chapter on Retention.

Fig. 36 is a modelling compound impression taken in an inefficient cast aluminum base-plate. A close inspection will show the muscle trimming, lines showing addition to the anterior flange, and a well-marked line showing the compressing portion added to the palatal border and tuberosities. That the student may appreciate the painstaking exactness such an impress requires, it is well to state that this individual impression was adjusted to the mouth probably fifteen times, but the final result was good.

IMPRESSIONS FOR ENLARGED RAPHE

Technique.—The impression for this class is the same as for the normal class, except in the palatal reënforcement wax.

The object sought with these enlarged raphe is to have contact without pressure. The palatal reënforcement wax is adjusted as in all cases, when a layer of the wax covering the hard raphe is removed to the extent of $\frac{1}{16}$ of an inch in thickness. If there is much thickness of soft tissue upon each side of the hard raphe, a little additional soft wax may be placed over the cold reënforcement wax covering the soft tissue of the vault, and readjusted to the mouth with moderately firm pressure. Should the anterior portion of the raphe touch the tray, it must be relieved by depressing the tray (use horn or wooden mallet). The tray is filled with soft plaster and placed in the mouth and pressure applied back of the middle of the vault of the tray. This will compress the soft tissue upon each side of the hard raphe. As a space has been made in the wax covering of the hard raphe, some of the soft plaster will be forced backward. This objectionable feature may be controlled by having the patient's head inclined forward.

FULL LOWER IMPRESSIONS

Classification

- High ridge
  - Broad.
  - Thin.
- Flat ridges
  - Broad buccal and lingual flanges.
  - Narrow buccal and broad lingual flanges.
  - Narrow lingual and broad buccal flanges.
  - Both flanges narrow.

Technique.—In all lower impressions the controlling factor for the width of the flanges of the tray will be the insertion of the mylohyoid and the frenum linguæ on the lingual, and the buccinator and labial muscles on the outer flange. A rule may be established that in no case shall the flange impinge upon a muscle.

High Ridge.—The only difference required for an impression for a broad or thin high ridge is in the wax reënforcement. With a broad ridge the reënforcement is upon the lingual flange only, while for a thin ridge both flanges should be reënforced. Fig. 37 illustrates a tray reënforced for a broad ridge, and Fig. 38 is prepared for a thin ridge.

Broad Ridge.—The operator should assume same position in respect to patient as mentioned in technique for upper impressions. After the flanges of the tray have been adjusted for a broad high ridge, a roll of soft wax, about the size of a lead pencil, is placed upon the warmed mandibular surface of the lingual flange, and inserted in the mouth in the same manner as described on page 69, except that the floor of the tray is upward. As the wax is pressed against the lingual wall of the process the patient is requested to raise the tongue momentarily to the roof of the mouth. The tray is removed, wax chilled, and excess cut away. It is then filled with soft mixed plaster and quickly adjusted in the mouth, by first adjusting the left side, and then the right side. As the

Fig. 37

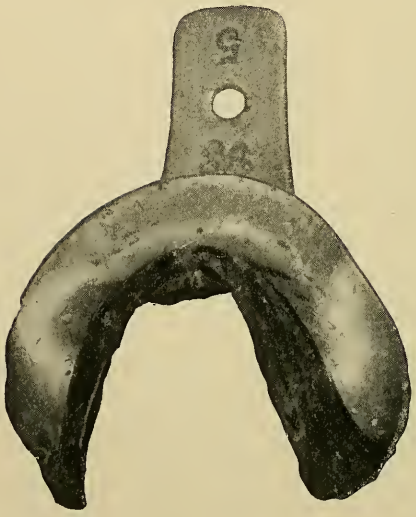
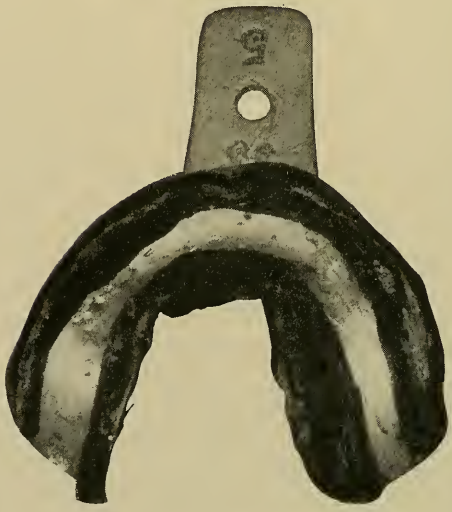


Fig. 38



left side of the tray is settled into position the finger used to distend the left angle of the mouth is carried backward, and with the thumb grasps the cheek, drawing it downward and outward, thus preventing a portion of soft tissue being entrapped under the buccal flange of the tray. The finger is then moved forward to the buccal frenum, which is distended, and then the labial frenum is drawn into place. The finger is removed and the left thumb inserted across the mouth as far backward as the angle of the mouth will permit. The fingers will be under the mandible, and the thumb resting upon both arms of the tray. As the right side of the tray is being forced into position, the right index finger having been carried into the mouth, the right cheek is grasped and drawn out of the way of the buccal flange. Pressure is then made over the border of the buccal and labial flanges with the fingers of the right hand. The thumb of the left hand is then placed upon the left side of the tray a little back of the angle of the mouth, while the right thumb is placed in a like position upon the right arm of the tray. As the fingers of both hands are pressing firmly against the under margin of the mandible the tray is held as in a vise. The patient is equested to raise the tongue firmly against the roof of the mouth, after which it may rest easily on the floor of the mouth. The tray should be he'd firmly until the plaster is set, when it is removed by grasping the hand'e with the right hand and distending the left cheek and lip with the index finger of the left hand.

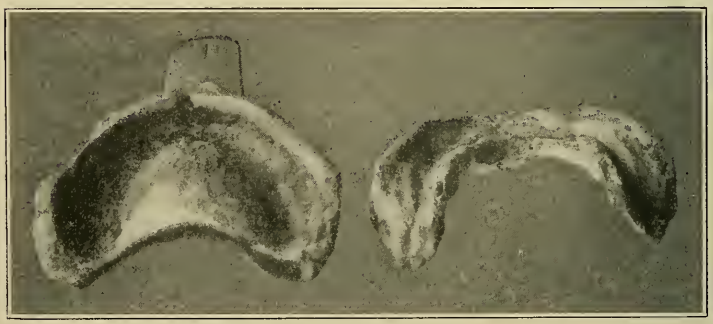
It is necessary to get the tray and tissues adjusted before crystallization of the plaster has much progressed, therefore it is desirable to have a definite system, so that no time may be lost. Every movement should be positive, but gently executed.

Thin Ridge.—The flanges of the tray having been adjusted, a roll of soft wax is placed upon each flange and pressed into position. The wax cooled and trimmed is shown in Fig. 38. The object sought in this impression is to have even compression upon the periphery of the base-plate while there is but slight pressure upon the crest of the ridge. This should relieve one source of pain in artificial dentures; that

is, undue pressure upon the mucous tissue drawn over a sharp crest of bone. If the thin ridge of gum has become pendulous, from excessive resorption of the process, it is well also to have it relieved of pressure. The plaster should not be mixed stiff enough to make pressure in any impression; the pressure should be made by the reënforcement wax. The plaster is designed for close adaptation.

Flat Ridges.—For these cases a series of oval floor trays should be prepared as the emergency demands. Two or three trays of different sizes prepared for this class of cases will probably be sufficient. The tray is prepared by cutting

Fig. 39



off the handle and about one-half of the flanges. They should be so trimmed that when they are placed in the mouth the muscles of the mandible will not much disturb them.

First Subclass.—(See classification for full lower impressions.) Either the regular oval floor tray with the flanges bent outward, or one of the specially prepared trays should be chosen, as best fits the case.

Second Subclass.—A regular tray with the lingual flanges bent inward and the buccal flanges rolled outward and upward will probably best meet the requirements.

Third and Fourth Subclasses will require the specially prepared tray.

The impressions of all of the flat ridge cases should be taken first in wax, or, better, in modelling compound. If

the patient can be prevailed upon to aid, the margins should be muscle trimmed. If the patient has not sufficient control of the muscles of the face so he can assist, the operator must hold the tray with the thumb of one hand so that the other hand is free to work the tissues. The right hand should hold the tray while working the tissues upon the left side, and *vice versa*. The patient can at least be prevailed upon to forcefully raise the tongue. This wax or modelling compound impression should be considered only as a reënforced tray. Grooves should be cut in the mandibular surface of the reënforcement when it is covered with soft plaster and inserted in the mouth. The buccal tissues must be removed from under the buccal flanges of the tray as directed on page 92. The impression should not be removed from the mouth until the plaster is thoroughly hard. As the impression is surrounded by saliva, there will be little danger of excessive adhesion.

Fig. 39 exhibits full upper and lower impressions of the broad type. The lower has the lingual flange reënforced and the upper has the palatal reënforcement.

PARTIAL UPPER IMPRESSIONS

Classification
- Anterior teeth lost.
- Posterior teeth lost.
- Teeth and spaces alternating.

Anterior Teeth Lost.—For all partial cases a flat floor tray of suitable size should be chosen. If three or more teeth are lost the vault reënforcement wax of Fig. 32 should be extended forward to nearly fill the space occupied by the lost teeth. There should be about $\frac{1}{8}$ of an inch of space between the wax and the remaining teeth, also between the wax and gum (Fig. 40). Judgment should be exercised in the quantity of plaster used, thus avoiding much excess. As partial plaster impressions are almost certain to be broken while removing from the mouth, a small tray (lacquer or metal) and tweezers should be upon the bracket table, so that the pieces may be placed in order as they are removed from

Fig. 40

Fig 41

the mouth. Figs. 49 and 53 illustrate such an arrangement. Fig. 41 is a tray properly filled with plaster for taking an impression where the four upper incisors are missing. The plaster should be mixed just stiff enough so it will not run when placed in the tray. This implies that, because of its stiffness, the time of setting is shortened, and that it must be quickly adjusted. In such a partial case the lingual

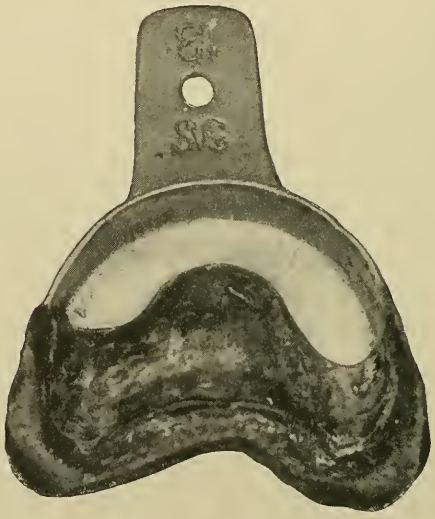
Fig. 42

aspect, and possibly the occlusal surface of the teeth, is desired. The buccal surface is not only not needed in the impression, but complicates the removal materially.

With the loss of any increasing number of teeth backward, the reënforcement wax is extended; the technique is the same as just described. Fig. 42 illustrates the wax reënforcement for the lost ten anterior teeth.

Posterior Teeth Lost.—This class implies that the remaining anterior teeth are in phalanx and that there are distally no isolated teeth. In such cases a flat floor tray should have the reënforcement wax as in Fig. 43. This prepared tray is for a case with the teeth lost distal to the first bicuspids. Fig. 44 has the plaster suitably placed.

Fig. 43



Teeth and Spaces Alternating.—Fig. 45 is a tray suitably reënforced. In all partial cases, except where wax contact is desired, there should be a space for plaster over the wax reënforcement of $\frac{1}{8}$ of an inch or little more. The alternating spaces may be dovetail-shape. In such cases cores should be made of wax to fill them. Fig. 46 is a plaster cast showing a space between the second bicuspid and second molar requiring a core. In the illustration the core is attached to the upper surface of the cast. The core is made by filling the space (without drying the teeth) full of soft wax. Most of the excess wax may be trimmed away in the mouth. The wax is

FIG. 44

FIG. 45

made cold and removed through the wider aspect of the space. In this instance it should be pushed inward. The wax is then thoroughly chilled and trimmed pyramid-shape,

Fig. 46

Fig. 47

with the base resting upon the gum. Fig. 47 shows the core in place. After it has been cooled and trimmed (pyramid-shape), so the plaster will draw from it, it is secured in place

by slightly pinching the occlusal end. If there are large spaces, as for the incisor teeth, the tray should be reënforced as shown in Fig. 40. After the impression has been removed from the mouth, the wax is carefully removed *and replaced in the impression.*

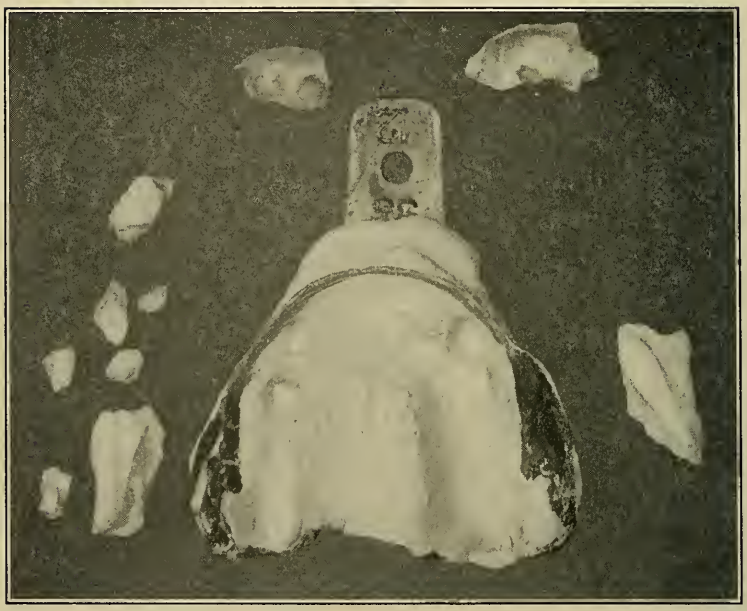
Isolated Teeth Method.—Fig. 48 shows a cast with the two cuspids and the left second bicuspid remaining. The teeth were short and firmly attached, so there was no danger of their extraction in the impression. In this case all the preparation necessary was the reënforcement of the tray as in Fig. 43. However, if the teeth had been long and bell-shaped,

Fig. 48

and loose, it would then have been necessary to have thoroughly dried the teeth (one at a time), and to have molded a little soft wax about the neck of each tooth as it was dried. The plaster impression would either draw away from the wax, when it should have been replaced in the impression, or the wax would have remained in the impression. Had the teeth dragged through the wax no harm would have been done other than a slight distortion of the wax. Fig. 49 is the impression taken for the cast shown in Fig. 48.

Some of the reënforcement wax is shown; also the fragments are placed in order about the main portion of the impression. Fig. 50 shows the assembled pieces luted together with wax.

Fig. 49



Detachable Tray Method.—In this method no wax reënforcement should be used, except as in Fig. 45; and this should be so trimmed that there are no undercuts. The maxillary surface of the tray and reënforcement wax are smeared with a thin layer of vaseline. This will permit the tray to part from the hardened plaster, which may be removed in sections after the manner used by orthodontists. The maxillary surface of the tray should be smooth, and in no degree dovetail-shape. If this method is to be used, the operator should first carefully observe the teeth and

vacancies, and devise a scheme for notching and breaking the plaster in sections. The notching and breaking is done with a stout knife which must be well guarded so the patient may not be injured. As the pieces are removed from the mouth they are placed in order on the lacquer tray. The impression tray may be removed from the mouth and

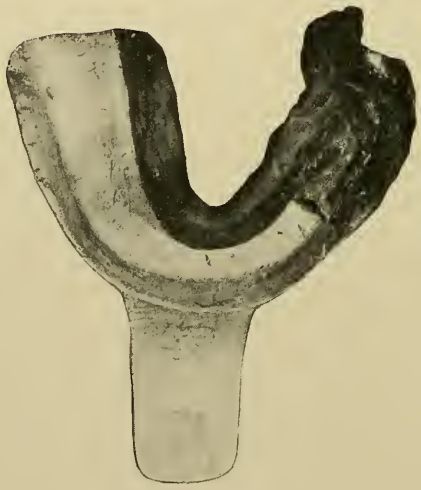
Fig 50

notches cut in the plaster, but no attempt should be made to break the plaster away from the teeth until it will make a clean break, that is, not crush. The inexperienced student should be very cautious of choosing this method, because of the danger from the knife. However, the tray may part from an impression unexpectedly, when it becomes necessary to notch and remove the impression in sections.

PARTIAL LOWER IMPRESSIONS

Classification.—The classification used for partial upper impressions is applicable for lower ones. The wax reënforcements are the same except that there is no vault and in place of a palatal margin reënforcement, a lingual flange reënforcement is required. Rarely should any lower impression (either partial or full) be taken without the lingual flange being reënforced. This is necessary to control the folds of

Fig. 51



the soft tissues, and the submaxillary and sublingual glands that are occasionally very troublesome. In all cases the mylohyoid muscle influences the loosely attached mucous membrane for a long distance above the origin of the muscle, and draws it inward and upward. As a result, if the lingual flange compression wax is not used the lingual flange of the completed artificial denture will not lie close to the mandible. This is often a source of annoyance to the patient.

Fig. 52

Fig. 53

Fig. 51 shows a flat floor lower tray with reënforcement. Fig. 52, with the plaster in place ready for insertion. Fig. 53 shows the impression with the fragments and a core. Fig. 54 is the assembled impression. Fig. 55 is a Weiss tray (a modification of the type shown in Fig. 22) and fragments. This tray requires the lingual flange reënforcement only. Fig. 56 is the assembled impression.

Fig. 54

Impression Aphorisms.—1. An impression constitutes the foundation upon which the success of an artificial denture depends.

2. A suitable impression can be obtained only by studying the case and devising a definite scheme of procedure.

3. A stock tray should be adapted to the individual case, by bending, trimming, and the addition of reënforcement.

4. Compression should be made through a properly formed tray. No impression material has discriminating power, hence cannot be depended upon to make suitable compression.

5. Plaster of Paris is the best impression material because of its plasticity, adaptability, rigidity, friability, and controllability.

FIG. 55

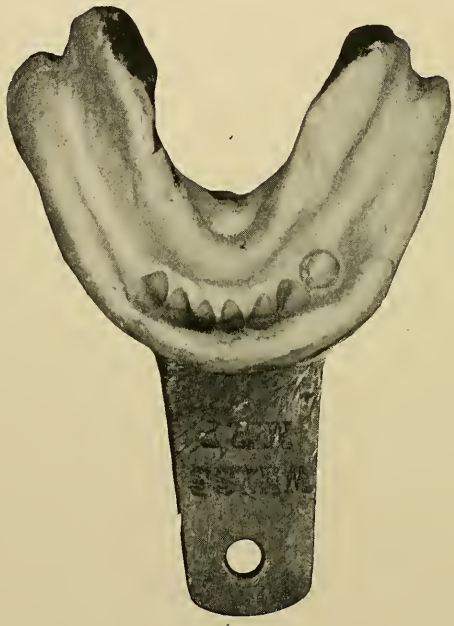
6. Modelling compound is valuable in specific cases because of its rigidity and workableness. It is very delusive because of its toughness.

7. An impression material is of value only as it is intelligently and skilfully worked.

8. Plaster of Paris is aseptic because it can be used but once. Modelling compound is dangerous because it may

be used repeatedly and cannot be sterilized by heat without destroying its working properties.

FIG. 56



9. Small simple impressions may be taken either in plaster of Paris, modelling compound, or wax. The accuracy will be in the order named.

10. The more difficult the case the more essential is the plaster-of-Paris impression.

CHAPTER III

CASTS

Definition.—A cast is a reproduction in plaster of Paris, its compounds, or some plastic material, of an object or part, made from an impression or mold. Casts are used to give their negative likeness to an artificial denture.

Unfortunately there is much confusion in dental nomenclature in the use of the term cast and model. There is no authority outside of the dental profession for calling a cast a model, as is too commonly done in vulcanite nomenclature; and such indifference in the use of technical terms can only lower one in the estimation of learned people. "Cast" is from *kasta*, throw, and is used in the sense of throwing, pouring, or forming a plastic material in a mold or impression. The term "cast" is applied to objects made of plaster of Paris, wax, and similar substances, while the term casting is usually applied to metallic objects formed in molds.

Model is from *modus*, measure, and is defined as an object representing accurately something to be made or already existing; a material pattern of natural, heroic, or diminutive size. Model is differentiated from pattern in that a pattern is usually flat, while a model has material contour.

In sculpture, the model is the plaster or clay original of the work to be executed in stone or metal; a person who does duty as a copy for painters or sculptors.

A sculptor may idealize his living model; but his workman must exactly copy the clay model made for him.

Even the dressmaking trade uses the term model correctly. They use a model to give its form to the human body, also to the external surface of the garment. It is only an incident that the garment is made over the model, for the object sought is to give form to the outer surface of the garment.

The photographer speaks of his negative, not of his pattern or model. If he uses the term model, he uses it correctly and applies it to his subject, not to the intermediate, the negative.

A dentist uses casts, castings, and models, and he should, if he is a member of a learned profession, differentiate and use his terms intelligently and correctly. A cast is anything formed, while in a plastic state, in a mold or impression; casting (noun) is a term applied to metal casts; and model is an object to be copied, but it is a positive, not a negative copy. Of all the arts, sciences, and crafts, dentistry alone uses the term in both a positive and negative sense. Such use is entirely inexcusable, because it leads to confusion of thought; besides, there is no dearth of correct terms in common use.

It is interesting to note the origin of this use of the term *model* in dentistry. At the time of the introduction of vulcanite, during the fifties of the last century, plaster models were in constant use for constructing dies for metal baseplates. As vulcanite work is constructed upon the plaster form in place of a metal form, it was only natural that the familiar term *model* should be retained for the new use. Unfortunately, the teachers and writers of text-books at the time of the introduction of vulcanite did not give sufficient thought to the philology of the glossary required for the new art; hence, some of the terms that have come down, even to this day, are not scientific.

A plaster model is never used in vulcanite work as ordinarily constructed. Plaster casts are used. A plaster cast gives its negative likeness only to the inner surface of a vulcanite denture, therefore cannot correctly be called a model. Orthodontists make plaster casts of cases as records of progress and completion. A plaster cast becomes a model only when it is used for duplication. The patient's jaws are the models, not their plaster reproduction.

Uses for Casts.—There are two general uses for casts in dentistry: (1) As a form over which something is constructed; (2) as a model or copy.

Materials for Casts.—The material for casts must be chosen with regard to the process to be employed. The materials may be classified as: (1) Plaster of Paris; (2) Spence plaster compound; (3) plaster compounds known as "investment compounds;" 4) wax and its compounds as models for metal castings.

Plaster for Casts.—From the study of the expansion, contraction, and compressibility of plaster, it is obvious that its use is limited, and that dental operations often require casts that are less subject to change by heat and pressure. While some operators are accustomed to use building plasters for certain purposes, it is better to select from the various compounds of plaster for dental use the one designed for the work at hand. Failures and imperfections due to the use of unsuitable material may thus be avoided. For all purposes, when little heat or pressure is to be used, French's *regular dental plaster* serves an excellent purpose. This plaster is found in all well-stocked dental supply houses, and is the only plaster carried by many of them.

Spence Plaster Compound.—This is an excellent preparation of plaster of Paris, Portland cement, and chemicals to control its setting and expansion properties. This material has four times the strength of dental plaster, and the expansion is nearly at zero. As the material is now placed upon the market, if properly worked, its setting time is about the same as slow setting dental plaster. Dr. Stewart J. Spence, of Chattanooga, Tenn. has certainly produced a very valuable material for casts which are to be subjected to moderate heat and considerable pressure. It is especially adapted for casts for vulcanite work.

It may be well at this time to consider tersely the important addition to plaster in the production of this compound.

Portland Cement.—This term was first used in 1824, and was given to a patented cement manufactured at Leeds, England. It is made by calcining and grinding a suitable mixture of lime and clay. It may be considered as a silicate of lime and alumina. There is a greater variety of cements grouped under the general heading of Portland cement than of plaster.

The student should not consider that any mixture of cement purchased upon the market and plaster will answer the same purpose as that bearing the name of Spence, because the Spence compound is the result of much study and experimentation.

Working Spence Plaster Compound.—The mixing of this compound with water is much more laborious than mixing plaster of Paris. The ratio of water to the compound, as now placed upon the market, is one to four. For a cast a fluidounce of water is placed in the plaster bow and three measured ounces of the compound are added and thoroughly spatulated with a very stiff spatula until it becomes soft and plastic, after which a half-ounce more may be thoroughly incorporated. The remaining half-ounce may be better added one-half at a time. It must be spatulated and kneaded in a bowl until the mass is putty-like in consistency, and if on continued working it becomes too soft, more of the compound should be added. When properly mixed it can be handled with the fingers and requires to be well-packed and jarred in filling the impression.

Investment Compound Casts.—This class of casts is designed to stand high heat, and must be made of a material suitable for its intended use. The supply houses furnish many of these compounds, which answer a good purpose. They consist largely of plaster of Paris for a bond to combine the material and such materials as will well withstand high heat, either singly or in combination. Of the materials used may be named: Sand (silica), clay, lime, asbestos, pulverized calcined fireclay, Portland cement, oxide of iron, pumice stone, chalk, etc.

Working Investment Compound Materials.—These materials are worked at about the consistency of plaster of Paris. Owing to the small quantity of plaster they contain, they will require much less water than pure plaster; usually one measure of water to three or four of investment compound.

Price's Artificial Stone.—This is a recent material invented by Dr. Weston A. Price, of Cleveland. It is a silicate cement, and when properly manipulated it becomes very hard,

strong, unchangeable, and will withstand the highest heat of any compound known in the dental laboratory.

How Worked.—The powder is mixed with the liquid accompanying it, upon a mixing slab, with a spatula. It is then formed into the mold or impression of wax, or over the wax model. It is permitted to set for a few hours, after which it is heated to a full red heat; it is then hard and unchangeable. It is excellent for that for which it is designed, but is not suitable for ordinary investments.

Wax and Compounds.—There are a variety of preparations in the dental supply houses composed of wax, paraffin, gum, and terpine. They are formed in a mold or impression, and then the wax cast is used as a model for producing a metal casting. This material is often carved into form for a model. Such a model cannot be spoken of as a cast because it was not formed in a cavity.

CASTS FOR ARTIFICIAL DENTURES

The construction of plaster casts only will be further considered in this chapter, but in discussing each variety of artificial denture the cast suitable for the work will be described.

Use of Impressions.—The preceding chapter treated of impressions and how to obtain them. This chapter treats of the use of the impression. All base-plate artificial dentures are constructed over either a cast or casting, therefore for each artificial denture it is necessary to obtain a suitable impression from which a cast is obtained. This implies that there is a technique for preparing the impression and making the cast.

Preparing the Impression.—A plaster impression is often broken in removing it from the mouth. Indeed, often a plaster impression can be removed only by fracturing. The property of being easily broken is one of the valuable features of plaster of Paris. This insures its removal and the accuracy of imprint when the fragments are assembled. The impres-

sion having been removed (if broken, the fragments arranged in order upon a small tray), it is permitted to dry for a few minutes (five to thirty), when, any small particles of plaster having been removed with an ox-hair brush, or a pointed instrument if necessary, the fragments are accurately readjusted in the impression tray and secured with melted wax (Figs. 50 and 54). If any carving is to be done upon the impression, it should be done at this stage of the procedure. However, as any carving must be done for a specific purpose, instruction as to where and how to do it can be given only in describing the work requiring such treatment. The impression is next treated with a separating fluid to facilitate the removal of the impression from the cast.

Separating Fluids.—The object of the separating fluid is to so treat the surface of the impression that a perfect counterpart of the intaglio may be formed of plaster or its compounds, and the two easily separated. This is accomplished by flowing over the surface of the impression some material that will prevent adhesion of the added plaster. The desirable properties for a separating medium are as follows: (1) It should add as little substance as possible to the surface of the impression; (2) it should provide a line of demarcation with a distinct penetration of the impression; (3) it should not cause chemical changes and injurious effects upon either the surface of the cast or the denture to be constructed over it; and (4) it should give a smooth glazed surface to the cast. There are a great variety of materials recommended and used for this purpose, but few are extensively used. They may be classified as: *Alcoholic solutions:* (*a*) shellac, (*b*) sandarac, and (*c*) other gums and terpenes added to these foundation solutions. *Aqueous solutions:* (*a*) liquid silex (silicate of soda), (*b*) soap, (*c*) borax and shellac, (*d*) ammonia or other alkaline substances and shellac. *Oils*, as sperm, lard, sweet, or vaseline; and *ethereal solutions:* (*a*) of soap and (*b*) collodion. The aniline dyes are used as coloring matter for some of these preparations. Many of these preparations are kept in stock by the supply houses, and some of them under fanciful names.

Perhaps the best and most commonly used method is to

first saturate the surface of the impression with a thin alcoholic solution of shellac, and when dry, to apply one or more coats of alcoholic solution of sandarac. These varnishes are made by dissolving one ounce of either gum in 4 ounces of alcohol. The solution is greatly facilitated by heating the uncorked bottle, containing the gum and alcohol in simmering water for a half-hour or until dissolved. The stock bottle should be kept well corked. If either varnish becomes too thick (by evaporation), it should be thinned with cold

FIG. 57

alcohol. The varnishes are applied to the impression with a camel's-hair brush. Each coat should be permitted to dry before applying another. The shellac varnish will penetrate and give a yellowish color to the plaster of the impression for $\frac{1}{32}$ of an inch, which is a warning of the approach to the cast when cutting away the plaster impression. This may be seen in Fig. 57. If the plaster is not well colored, it should be given another coat of shellac, after which it is given one or more coats of sandarac varnish. The shellac penetrates and gives depth of color line, and the sandarac remains upon the surface and forms a glaze.

Pouring the Impression.—This is a common term used for filling the impression. The term is slightly misleading in that it implies that the plaster mix is poured into the impression. The plaster batter should be a little thicker than for an impression and a trifle too thick to pour. However, it must not be so stiff that it will not flow perfectly over the surface of the impression when jarred by rapping the tray lightly upon the table. The same rule (as to the ratio of water and plaster) is used for casts as for impressions—that is, one measure of water and two measures of regular dental plaster. If the mix seems too thin, more dry plaster should be added until the mix will stand as placed. However, it must have a pronounced glossy or watery appearance, and when this characteristic diminishes it is evidence that either too much plaster has been added or that crystallization has commenced. The surface of the impression should be thoroughly covered before this deadened appearance begins. The student should observe carefully the appearance of his plaster mixes, because the quality of the cast depends much upon the manipulation. An excessive amount of plaster added to the water or overspatulation interferes with the process of crystallization, thus causing increased expansion and reduced strength of the cast.

Technique for Filling the Impression.—The surface of the impression having been properly varnished while dry, it should then be immersed in water until bubbles cease to form, the plaster gauged, and smoothly and quickly mixed; a portion of the mix (about a teaspoonful) is placed upon the higher central portion of the impression and caused to flow into the lower portions of the intaglio by rapping the tray three or four times upon the plaster bench. Portion after portion of the mix is added and jarred into position until the intaglio of the impression is full, when the jarring ceases and the remainder of the mix is piled on and spread with the spatula until the plaster forming the cast is about one-half inch thick over the highest portion of the vault.

Shape for a Plaster Cast.—For the sake of convenience it is well to adopt such a form as will be best adapted to the

various uses to which a cast may be put. A suitable form not only favors and expedites future operations, but in some cases it affords additional strength. The form affording the greatest usefulness is the truncated cone. This form is easily given to the cast by inverting the tray while the plaster is somewhat soft and gently pressing it down upon

FIG. 58

any smooth surface, as a slab of marble, glass, or metal. If the base of the cast is formed upon any rigid material, the surface should be slightly oiled, to facilitate the removal of the plaster. (A convenient arrangement is to have a 6-inch square block of wood covered with sheet zinc. This will need no oiling, for the sheet metal is flexible and will yield to pressure applied at the sides of the cast.) After

the filled tray is inverted upon the smooth surface the plaster spatula should be passed about it, producing a smooth and symmetrical outline. The truncated cone form of an upper cast will not be a symmetrical truncated cone, for its base will be a parabola; and the lower one will be horseshoe-shape. Instructors are accustomed to direct that the base of a lower cast should be made solid (for strength) in place of a horseshoe-shape. It is better to sacrifice a portion of the strength of the lower cast for the convenience obtained in antagonization of the teeth. Fig. 58 illustrates properly formed upper and lower casts.

Separating Cast from Impression.—There are three steps to this operation—(*a*) removing any plaster overhanging the edge of the tray, (*b*) removing the tray from the impression, and (*c*) removing the impression from the cast.

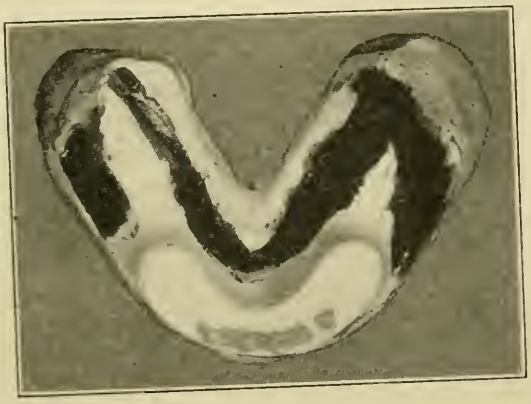
A sharp plaster knife is used to cut away any overhanging plaster so that the outer edge of the tray is visible.

If the impression is either wax or plaster, the outer surface of the tray should be slightly warmed over a Bunsen flame. The heat applied to the tray will soften the wax in contact with the tray, and the two may be easily parted. The plaster impression is as easily removed from the tray as a wax one, provided heat sufficient to soften wax is passed through the tray (Fig. 59). This is probably accomplished by slightly expanding the metal of the tray, and also by generating a small amount of steam between the tray and plaster, or at least the expansion of the moisture upon the surface of the impression next to the tray. A modelling compound impression can be readily removed by rapping upon the outer surface of the tray. If the tray is of such shape that the two are dovetailed together, the rapping method may not suffice, and heat should be applied. This can be best done by placing it in a dish of cold water and applying slow heat. Care must be exercised not to apply too much heat or the modelling compound will be made very adhesive and will adhere both to the tray and cast.

Separating the impression from the cast can be neatly done by the exercise of care. Wax should be slowly warmed

over a soft flame, and modelling compound in water. Either material should be removed from the cast by lifting the outer portions and turning them over upon the central mass when it is easily removed. While a separating fluid is not necessarily applied to wax and modelling compound impressions, nevertheless, if a thin coat of sandarac is dried upon either impression before filling, it does facilitate the removal of the impression material, provided it has been slightly overheated.

FIG. 59



Plaster impressions may be groupee into two classes to conform to as many procedures for separating them from their casts: (1) Flat impressions without undercuts. It is not necessary to remove these impressions from the tray, but by holding them with the cast downward and gently rapping upon the tray they will drop from the impression. (2) Prominent flaring processes. The plaster impression should be carefully pared away, with a sharp plaster knife, over the crest of the alveolar process, until the shellac line of demarcation is visible. The outer flange of the impression may then be flaked away. The remaining central portion, provided it is not keyed into place, may be lifted out by inserting the point of the knife or a wax spatula under any

convenient edge of the impression. Should the central portion not yield to reasonable force, it must be carefully notched along the median line, when first one half and then the other may be pushed inward.

Casts of Partial Cases.—The principle of construction of partial cases is the same as for full cases, but the technique varies to suit the conditions. Care must be exercised, in applying the separating fluid to the imprint of the teeth, that every portion may be thoroughly covered. This may be facilitated by applying an excessive amount of fluid, and using a rotary movement of the brush, or it may be applied with a pledget of cotton held in a pair of tweezers. While drying, the impression should be inverted so that any excess may not settle into the depressions of the impression. If the impression has been standing for a half-hour it should be dipped in water and the excess water shaken out just before filling. If the impression has been standing for several hours, it should stand in water for three or four minutes before filling. This will aid the flow of the plaster and help to prevent air bubbles forming in the plaster of the cast. The filling plaster should be caused to flow down one side of the deep depressions (as the intaglio of the teeth), thus permitting the air to escape from the other. It is well also to have a tamping stick to press into the imprints of the teeth. (A small riveting hammer handle with the head cut off at the smallest part of the neck is an excellent tamper. Use either end as convenience requires). Each added portion of plaster should be jarred into place. Much care is required in removing the impression from the cast. It must first be carved down to the shellac line of demarcation before any attempt is made at breaking away the impression. An excellent way, used by many for strengthening isolated plaster teeth of a cast is, as soon as the intaglio of the tooth is filled with soft plaster, to force into the centre of each tooth, for its entire length, a pin or a small diameter $\frac{3}{4}$-inch wire brad. Fig. 57 shows a plaster cast with the plaster about the isolated teeth carved ready for breaking away the impression. Fig. 48 shows the cast.

Repairing Broken Casts.—Plaster casts may be broken accidentally. These may be nicely and strongly mended by uniting the sections with moderately thin, well spatulated

FIG. 60

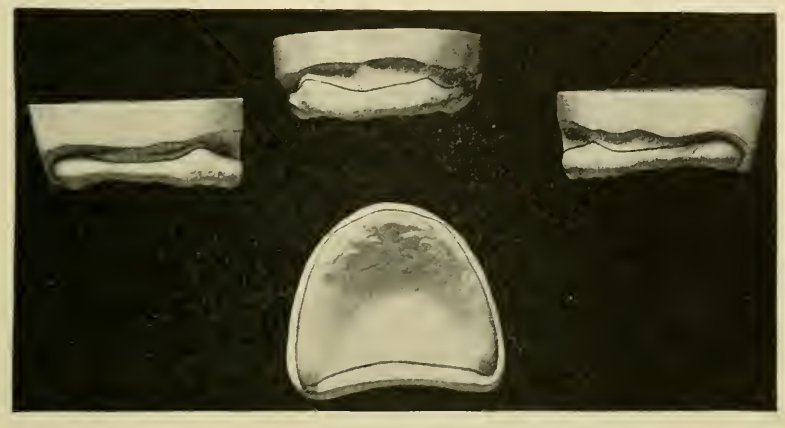


FIG. 61

oxyphosphate of zinc cement. The sections should be supported until the cement has set sufficiently to be unyielding to the weight of them. The cast should then be undisturbed for at least a half-hour. If the cement is properly

mixed and the portions of the cast are well pressed together, the resulting union should be very strong.

Base-plate Outline.—With a soft lead pencil the outline of the periphery of the denture is traced upon the cast. Figs. 60 and 61 show the base-plate outlines for an upper and lower denture.

Fig. 62

Fig. 62 illustrates knives for cutting plaster. *A* is a common form; *B* is a Wilson knife having a $2\frac{5}{8}$-inch draw blade and a $1\frac{3}{8}$-inch push blade; *C* is a saddler's knife. The saddler's knife is a powerful tool for trimming the base of casts only. It is used with a rocking motion. All plaster knives need frequent grinding, as plaster, and especially Spence compound, quickly blunts the edge.

CHAPTER IV

OCCLUSION AND CONTOUR MODELS

Use.—Occlude, to strike against or close. This term is used to represent the teeth closed in their natural position of ease and rest. In this state the condyles of the mandible are in their most retruded position in their glenoid fossæ, except in a few cases of acquired abnormal condyle articulation. It is apparent that to construct an artificial denture much data, other than a cast of the jaw upon which a base-plate is to be worn, is necessary, in securing which the occlusion model is an important factor. This occlusion model is a mass of material roughly outlined, and indicating the normal (probably the natural) relation of the teeth and jaws while at rest. The term "contour" is added to the title to imply that the mass of material has been molded or carved to such a form as will give the desired contour to the external soft tissues of the lower third of the face. Therefore, if this mass of material which we call the occlusion and contour model is truly a model pattern it must be accurately reproduced in the essentials which it represents. However, this does not mean that the forms of the teeth should be carved in these models because the teeth are not to be made by the prosthetist (they may be obtained of the trade in much better form and strength than would be possible to produce in the dental laboratory); but it does mean that the lines indicated by the occlusion and contour models are to be permanently retained. This implies that thought and technique are to be employed in constructing these models. The student should have fixed in his mind the idea that the two primary objects of these models are to establish the position of the artificial teeth when at rest, and to give

harmonious contour to the soft tissues covering the artificial dentures. In addition to these primary factors they are used to record other important data, such as the high and low lip lines, also the median line and the slit of the lips. They may record the plane of the teeth, and aid in establishing the condyle path; or they may ignore the plane of the teeth and establish the condyle path.

Materials Used.—Wax and its combinations, modelling compound, gutta-percha, resinous preparations, and possibly plaster of Paris, may be named as the materials of which occlusion and contour models are made. These materials are used by the profession in the order named. The materials are attached to a base-plate, either a temporary one or the base-plate upon which the teeth are to be permanently mounted.

Wax is most commonly used as well as most misused for the purpose under consideration.

THE BITE

This term is generally used in connection with the use of wax for obtaining the relation between the jaws and teeth. The word bite is of Anglo-Saxon origin, and means "split;" hence it is used in the sense of cut, lacerate, take severe hold of, and similar ideas. As applied to dental technology, it means to cut into a mass of soft wax with the teeth or bare gums. The term is inelegant and unscientific, and except for a very limited use it is non-expressive and associated with pernicious methods. The term should never be applied to occlusion and contour models. The term wax-bite is known by several other inelegant terms, as mush-bite, quash-bite, hunk-bite, and like terms. They all refer to the common practice of placing a mass of wax in the mouth and requiring the patient to bite into it. *To bite, cut:* As in 95 per cent. of cases the upper incisors overlap the lower incisors, to bite or cut means to bring the lower incisors forward and in contact with the upper incisors, thus inviting the patient

to do the thing that is the *bête noire* of the dentist in mounting artificial teeth. The first requirement in obtaining the desired relation between the jaws and teeth is that the mandible shall be in its most retruded position. There is but one class of cases where the prosthetist should ever use the quash-bite, and that is where there are two or more natural teeth that have the required occlusion, but not enough points of contact to support the casts while being attached to the *articulated frames.* If contour and other data provided by occlusion and contour models are not desired, then, and then only, may the quash-bite be used advantageously. As an illustration of an appropriate place to use a quash-bite, an imaginary case may be considered, consisting of a full lower natural denture and the six anterior, right first bicuspid and left second molar remaining in the upper jaw, the bicuspid and molar only in occlusion. Such a case would be the most favorable imaginable for casts with only two points of contact being self-sustained; and it is surprising to the student, no matter how he may have bolstered the casts with pieces of wax before mounting on the articulated frames, to find how much the finished dentures may be off from perfect occlusion. This is easily understood when consideration is given to the points of contact as fulcra and the distant positions for the left first bicuspid and right second molar as ends of a lever. A very slight movement at the fulcra will mean relatively a large amount at the ends of the lever. A modification of this supposed case would be having the retained second molar upon the right side, it would then be evident that some means of establishing the relationship of the left side would be necessary. As a result of the consideration of these imaginary cases this rule may be established: All partial cases, unless they have three or more widely separated points of occlusal contact, require occlusion guides. Quash-bites may serve an excellent purpose as occlusion guides. A suitable quash-bite for the case just considered would be to form a crescent-shaped mass of soft wax of a little greater thickness than the space between the teeth of the lower

jaw and the gum of the upper jaw, and having embedded in it a 14-gauge soft iron wire stiffener. This prepared mass of wax is placed just inside the anterior teeth, with the ends occupying the edentulous spaces. The patient is then instructed to close and hold the teeth together firmly. The operator should press against the extruding wax, molding it firmly against the buccal surfaces of the teeth and gums. The patient is then instructed to open the mouth moderately wide, when the operator should remove the wax with as little distortion as possible. It should then be made hard by placing in cold water, after which it is dried, trimmed of excess wax, and a small roll of soft wax placed in the imprint of the gums. It is then readjusted in the mouth and the mouth firmly closed upon it. This will correct any imperfections caused by manipulating the soft mass of wax. In using this wax occlusion guide care should be exercised to see that excessive portions of plaster or wax do not prevent the plaster casts going fully to place. Usually the casts or wax guides will require considerable trimming to permit of adjustment.

Occlusion models require a well-adjusted base-plate. The base-plate of the artificial denture being permanently constructed is the very best that can be provided for occlusion models. In fact, the best results can only be obtained in artificial dentures by first constructing the base-plate. This statement will invite disagreement, nevertheless the statement is tenable and will be demonstrated. However, where the single vulcanization method is to be employed in making an artificial denture, a temporary base-plate will necessarily be constructed for the occlusion model. There are several materials used for this purpose, as $\frac{1}{16}$-inch thick sheets of wax, paraffin, modelling compound, gutta-percha and "ideal base-plate," and similar preparations obtainable at the supply houses. These preparations are composed of shellac or a similar substance.

Methods for forming a base-plate of tin are used by a few operators, as swaging a base-plate of sheet block-tin, and by burnishing tinfoil over the cast. Excellent results by

the burnishing method may be obtained by the following technique: Adapt a sheet of No. 20 tinfoil to the plaster cast with the fingers and thumbs; the surplus is cut away with scissors, after which the tin is burnished with a steel or agate burnisher. Care should be exercised not to use sufficient force to mar the face of the cast. A second sheet is adapted to the burnished sheet by the fingers and thumbs, removed, and trimmed. A small dab of thick sandarac varnish is placed upon the centre of the burnished sheet when the second sheet is readjusted and burnished, beginning at the centre and working outward. Layer after layer is thus added until the required thickness is obtained. After the first sheet of No. 20 is adjusted a heavier foil may be used if preferred.

Paraffin Base-plate.—Paraffin is found in the supply houses in the form of thin sheets put up in half-pound boxes. It is usually called pink wax because of the color the manufacturers have given it. This material is used by slightly warming it over a smokeless flame and adapting it to the plaster cast. The excess base-plate wax is trimmed away with a warm wax spatula at the indicated peripheral outline of the artificial denture. An excellent addition may be made to this paraffin base-plate by first adapting a sheet of tinfoil to the cast. This will prevent the paraffin, if overheated, from adhering to the cast, and also add some rigidity to the base-plate. The principal objection to wax or paraffin as a base-plate is that it is not rigid enough to retain its form while adjusting the occlusal model, and later the mounted teeth, to the mouth. For this reason some operators make this temporary base-plate of modelling compound, gutta-percha, or of the various resinous preparations offered for sale. The temporary base-plate having been formed over the cast, it is well to try it in the mouth and prove the correctness of its adaptation and peripheral outline. This is not very satisfactorily done with the less rigid base-plate, but with the permanent base-plates of vulcanite or metal it is a most important step in the procedure. Mention is made of this fact to impress the idea that the most commonly

used method is the most unsatisfactory and unreliable one. The base-plate (when adjusted) is removed from the mouth, dried, and replaced upon the cast, a roll of softened pure yellow wax is molded over the ridge of the base-plate to the estimated length and fulness of the lip, when it is tried in the mouth and manipulated to the required contour. (The full details of contouring the occlusion model can only be properly considered under the subject of Esthetics, Chapter XVI.) The edge of the wax rim should come to, and thus indicate, the slit of the lips. If the occlusion model is an upper one to be adapted to a full lower artificial or natural denture, the occlusal border of the wax rim must be trimmed to evenly press upon the opposing denture. It is not necessary to trim so as to have perfect contact of the occlusal border, but there must be at least four well-spaced points of contact, then a small flattened roll of soft wax placed along the occlusal border and closed upon will make perfect contact. If the occlusion models are being formed for an upper and lower edentulous case, the occlusal border should represent the plane of the teeth (see Chapter I). This is accomplished by having the occlusal border of the upper model exactly at the slit of the lips and extending straight backward parallel with the imaginary line drawn from the base of the nose to the lower border of the external auditory meatus, or the line dividing the middle and lower thirds of the face (Fig. 1).

Modelling Compound Technique.—The following description is a quotation from Dr. Charles R. Turner, in the *American Text-book of Prosthetic Dentistry:*

"**For the Upper Jaw.**—To construct a bite-plate of modelling composition for the upper jaw, the cast should be placed upon its base on the work-bench with the distal portion toward the operator. The method of making the bite-plate in one piece proposed by Dr. W. W. Evans is to be recommended. Three-fourths of a cake of modelling composition is softened in warm water, kneaded in the hands until homogeneous, and rolled into an ellipsoid about two inches long. One side of this should be thinned out by pressure between

the fingers, and the mass so placed upon the cast that the thinned portion projects slightly beyond the posterior margin of the plate outline. By manipulation with the thumbs the remainder of the compound is gradually worked forward so that the vault of the cast is covered by it to the thickness of about $\frac{3}{32}$ of an inch. The thickness of this may be readily gauged, for the cast chills the material as it comes in contact with it, thus hardening it, while the overlying soft portion may be pushed forward. When the top of the alveolar ridge has been reached, the compound should be carried over it and slightly beyond the plate outline, along the labial and buccal surfaces, the most of the mass, however, remaining upon the ridge and being shaped to represent the occlusal portion of the bite-plate. The probable relation of this part of the artificial denture to the alveolar ridge and the probable fulness of the buccal and labial portions should be borne in mind and the compound disposed accordingly, since the bite-plate when completed should be a rough model for the denture in these particulars. It should be taken from the cast, chilled in cold water, and trimmed around its periphery to the plate outline. It ought then to be replaced upon the cast and its margin brought into close contact therewith, around the plate outline. This is to insure firm retention of the plate in the mouth, which is of the greatest importance, and should be secured, even if it be necessary to make at this time the changes in the surface of the cast which provide for the adhesion of the future denture. The form of the bite-plate at this time is largely tentative, as it is purposed to complete its modelling when the bite is taken, in accordance with the requirements which shall then be indicated. During the process of forming the plate, to prevent adhesion, the hands should be wet and the compound occasionally taken off the cast to break up its adhesion while it is soft, and then replaced, but under no circumstances must the cast be wet, as this will injure it for subsequent use. Rubbing its surface with soapstone or talcum powder will effectually prevent the adhesion of the compound.

"It is possible to construct the plate in two portions, that in

contact with the mucous membrane being made of one piece of modelling compound rolled into a thin sheet and adapted to the cast, that representing the occlusal portion being formed of a roll bent to the shape of the alveolar ridge, and made to adhere by dry heat. The occlusal portion is made of wax by some practitioners because of the greater ease with which it may be carved, but its softness and tendency to yield under pressure make it less safe than modelling compound in preserving a fixed distance between the jaws.

"**The Lower Bite-plate.**—The lower bite-plate is more easily made than the upper. With the cast face up on the work-bench, a piece of compound equal to about one-half of a sheet is softened and worked into a long uniform roll, bent to the shape of the alveolar process, and placed upon its summit. With the thumbs and fingers it is worked down the lingual and labial sides to a point slightly beyond the plate outline, that portion over the ridge being shaped to represent this part of the future lower plate and made to correspond in outline to the arch of the upper bite-plate. It is removed and trimmed to the plate outline like the upper, its occlusal surface being left rough. If the lower plate must be very thin, it may be strengthened by embedding in it a piece of iron or brass wire shaped to conform to the alveolar outline."

Modelling Compound Base-plate.—The preceding method, as described by Dr. Turner, consists of forming the base-plate and occlusion model of one piece. Another method is to form the base-plate of a thin sheet of modelling compound and building up the occlusion and contour portion with yellow or pink wax.

Technique.—The plaster cast is covered with a sheet of tin-foil or pattern tin, by adjusting the tin with the thumb and finger. It is not necessary to adjust the foil accurately, for the following step of adapting the modelling compound will perfectly adjust the foil. The modelling compound should be rolled or pressed into a sheet $\frac{1}{16}$ to $\frac{3}{32}$ of an inch thick. The sheet may be formed by rolling with a moistened wooden roller or pressing it with the fingers upon a warm

plate of glass. The glass slab should be slightly lubricated with vaseline, or moistened with water, to prevent adhesion. The warm and pliable sheet of modelling compound is quickly and accurately adjusted to the plaster cast over the tinfoil, and trimmed to the peripheral outline of the desired plate. The tinfoil serves a double purpose; it renders easy the removal of the base-plate from the cast, and prevents soiling of the cast should the compound be overheated in any subsequent operation. Any portion of the modelling compound base-plate that may not be perfectly adjusted may be perfected by passing repeatedly over the Bunsen flame and conforming with the fingers slightly moistened.

Gutta-percha and the Resinoid Preparations.—These are obtained at the supply houses in sheets about $\frac{3}{32}$ of an inch thick. They are both manipulated in the same manner as the thin sheets of modelling compound, and will not need further description.

Vulcanite Base-plate.—This form of base-plate is applicable only where there is considerable recession of the alveoli. It is apparent that a vulcanite base-plate must have considerable thickness for strength and rigidity; and admit of sufficient added material to attach the teeth and to give the indicated restoration without overdistending the supported soft tissues.

The advantages of a vulcanite base-plate are: (1) It detects a faulty impression before much work has been done. (2) It permits study of the retention of the artificial denture. If it is evident that the impression was defective, or that the devised scheme for retention is insufficient, a new impression may be taken and the mistakes corrected without much loss of time and labor. (3) It gives stability and proper support to the subsequent operation of construction.

The only disadvantage in the vulcanite base-plate, where it is indicated, is that the finished artificial denture has a portion of its substance overvulcanized, consequently it is harder and more brittle than it would have been if vulcanized but once. This slight weakening of a portion of the vulcanite will do no harm provided the appliance is correctly

constructed. However, the student should know that it is essential that the heavy bearings of the base-plate upon the tissues must be properly located, and that there is danger of warping in the second vulcanization. This phase of the subject will be considered in the technique of double vulcanization.

Vulcanite Base-plate Technique.—A suitably prepared cast of plaster of Paris or Spence plaster compound having been obtained, it is preferably (though not necessarily) overlaid with a sheet of thin tinfoil, after which a sheet of slightly softened paraffin (pink wax) is accurately adjusted to the cast over the tin protection. The excess wax and tin are cut away at the previously indicated peripheral outline for the base-plate. The edge of the wax base-plate is then carefully sealed to the cast with a hot wax spatula. An additional layer of wax may be added over any portion of the base-plate, at the discretion of the operator. Such an addition is especially indicated over the crest of the lower base-plate as a means of obtaining sufficient stiffness.

Fig. 63

The cast and model base-plate is flasked in a Star or Wilson flask, the flask opened, model base-plate removed, surface of the cast finished, (either silex or tin), packed with rubber, flask closed, and the case vulcanized. After the vulcanization is complete and the vulcanizer cold, the base-plate is removed from the flask, cleaned of plaster, the edges filed, and the outer surface scraped to give a suitable surface for the attachment of the rubber at the time of second vulcanization. The inner surface, or the surface to rest upon the soft tissues should not be changed except to remove any excrescences

produced by defects on the surface of the cast. Fig. 63 shows a vulcanite base-plate.

This outline sketch has introduced several laboratory processes, which will be discussed in their proper place.

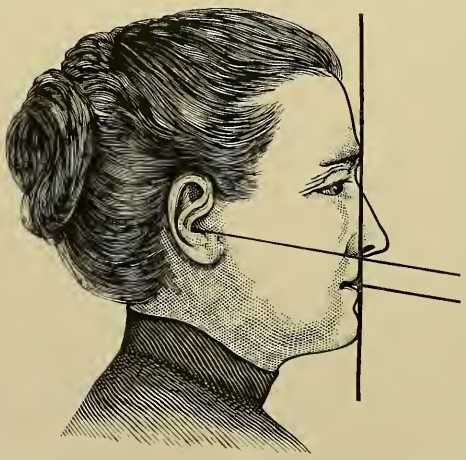
Metal Base-plates.—When an artificial denture is to be constructed upon a metal base, the base-plate is formed either by the casting or swaging method. It is obvious that the base-plate constructed as a component part of the finished artificial denture is the very best base-plate for the occlusion and contour models. Therefore, the vulcanite and metal base-plates are to be much preferred to the temporary base-plates formed of wax or of the gum or resinous preparations.

OCCLUSION AND CONTOUR MODELS

The base-plate, of whatever material, having been adjusted to the mouth, the walls of the model are to be built up of either pure yellow beeswax, white wax, pink wax (paraffin), or modelling compound. Their rigidity is in the inverse order as named. The ease of manipulation is in the order given. The yellow wax is the least rigid, but because of its ease of manipulation it is most commonly used for building up the occlusion walls. The student should constantly bear in mind this one deficiency of yellow wax, although the material is commended to him because of its desirable properties for subsequent procedures. No matter, at this time, which material is selected, the material will be manipulated in the same manner, so far as construction is concerned. Having placed the base-plate on the cast, a cylindrical roll of the softened material of sufficient length to cover the crest of the alveolar ridge, and in diameter varying from $\frac{1}{4}$ to $\frac{3}{4}$ of an inch, according to the amount of space to be filled, is conformed by manipulating with the fingers and thumbs to the ridge portion of the base-plate. The plastic material is luted to the base-plate by the use of a hot spatula. The labial and buccal surfaces are added to or carved away as may be necessary to give the required contour for the support of the

lip and cheeks. This first shaping is entirely by guesswork; however, this is only to give it general form for trying in the mouth. The esthetic manipulation of the plastic material to the mouth will be treated of in the chapter on Esthetics. The occlusal surface of the plastic rim must be a perfectly flat surface, and as this edge forms the occlusal plane or teeth plane, it must be correctly located. The perpendicular length of the plastic rim is indicated by the length of the lip, and is located by the slit of the mouth when the lips are perfectly relaxed and at rest. The slit of the lip marks the

FIG. 64



anterior border of the plastic rim, but from that point backward the length is indicated only by the naso-auditory-meatus line (see Fig. 1, also Chapter I). The occlusal surface is carved from or added to until the required plane is obtained. The method of testing this wax plane is to place the occlusion model in the mouth, and a straight edge placed against the occlusal surface and extending 4 inches from the mouth will indicate whether the occlusal surface of the occlusion model is parallel with the naso-auditory-meatus line or not (Fig. 64). Should the student have

trouble in carrying this naso-auditory-meatus line with his eye, he can stretch a string so as to include the two points named, thus ascertaining whether the string and straight edge are parallel or not. A suitable straight edge may be formed of a thin sheet of metal, horn, or vulcanite. It should be 2 inches wide at one end and 6 inches long. After the correct occlusal plane has been established and any deficiencies noticed filled in, the occlusion model is pressed upon a flat surface with sufficient force to give a true even plane to the occlusal surface of the model. At all times, in using any force upon a base-plate, it should be upon the plaster cast, thus avoiding any possibility of warping. Prevention is always better than remedying.

The upper occlusion model having been perfected, it is removed from the mouth and placed in cold water.

The lower model is built up in the same manner as the upper and then adjusted to the upper in the mouth. The upper model is kept in cold water except during the few moments at a time that it is needed in the mouth while adjusting the lower. By keeping the upper model cold and rigid, all change resulting from closing the mouth will be in the softer, lower model. The lower model must be manipulated until it has a suitable vertical length, contour, and an even pressure upon the occlusal surface of the upper model. The occlusion models having been satisfactorily adjusted, they are removed and placed in cold water to thoroughly chill.

The patient should be instructed regarding the next step of the operation, that is, retruding and protruding the chin. Often it will require considerable time and patience to educate the patient in placing the chin as requested. It is not necessary; in fact, it is better that the patient should not place the chin in the extreme protruded position. They should place it in the extreme retruded position and protrude it at least one-fourth of an inch. A hand mirror is often an aid to the patient in learning to protrude and retrude the chin. If the patient does not readily do as requested, the operator may demonstrate with his own

mouth the desired movements. The patient having become proficient in the exercise, the occlusion models are adjusted in the mouth. Should either of the models be refractory and not keep its place, it may be temporarily "glued" into place by sprinkling the inner surface with powdered gum tragacanth. The patient is requested to retrude the mandible and close the jaws, then to protrude and close. These instructions being satisfactorily obeyed, the patient is requested to retrude the mandible, close the jaws, and hold the occlusion models firmly together. The head is then moderately tilted backward. The patient is requested to swallow. The act of deglutition necessarily places the mandible in the retruded position. While the occlusion models

FIG. 65

are thus firmly occluded, the lips are parted and the median line of the face is marked upon both models with a sharp instrument. The patient is requested to raise the upper lip as high as possible by muscular action. Then a horizontal line is made indicating the highest point at which the lip can be raised. The lower lip is depressed and the low lip line traced. The cheeks are distended and two perpendicular or oblique lines are drawn upon each buccal surface. These buccal lines must extend into both the upper and lower models and are used as location marks only (Fig. 65). There are now registered upon the occlusion models the slit of the lips, the median line of the face, and the high and low lip lines. Besides these lines used in mounting the teeth,

there are four buccal lines used in conjunction with the median line to properly assemble the models when out of the mouth.

Condyle Path.—The next record to be made by means of the occluding models is the condyle path. By reference to Figs. 2 and 5, and Chapter I, it will be seen that there is a great variation of the condyle path, that the principal portion of the path is a straight and more or less oblique line, but if the mandible is protruded to its extreme position the condyle has described a "straightened out" letter S rather than a nearly straight line; therefore, in taking this measurement the extreme protrusion is not desired, but one-fourth of an inch or a little more will include the portion required. It is obvious that if the condyle moves forward and glides down the eminentia articularis, and the incisal portions of the occlusion models are brought together, the distal or molar portion

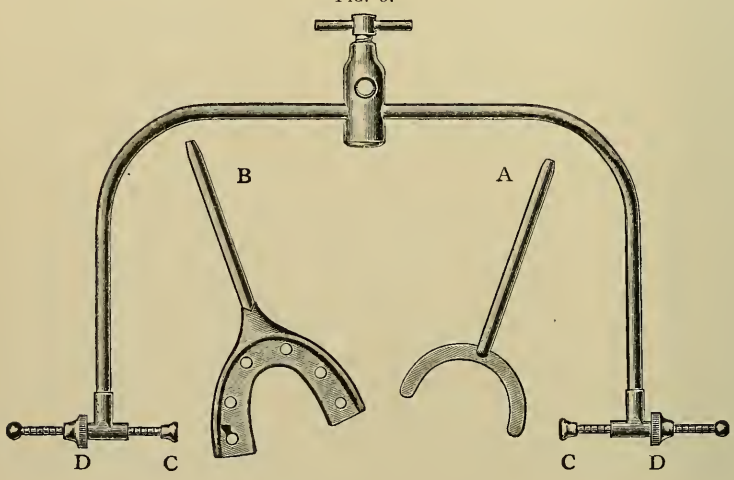
Fig. 66

of the occlusion models cannot be in contact; also that if a measure is taken of the forward movement of the mandible and of the separation of the distal portion of the models, sufficient data is obtained to reproduce the condyle path. These measurements are easily obtained with Dr. Snow's "bite gauges" (Fig. 66). The bite gauges consist of a small plate of metal with the under side so formed as to be easily attached to the occlusal surface of the lower model; the upper surface of the bite gauge carries a blunt metal spud. A bite gauge is mounted at each end of the lower model by wetting the metal and pressing it, flush, into the occlusal surface of the model. The patient is told that when the lower model is replaced they are to protrude the mandible and close the jaws until the incisal portion of the models are in contact. By this means the spud on top of the bite gauge will be forced part way into the occlusal surface of the upper model, thus in one operation marking the forward position of the mandible and

the distal separation of the occlusion models. The lower model is removed from the mouth and the bite gauges carefully removed so as not to distort the marks made by them. At a future time these bite gauges will be returned to their place in the occlusion models and establish the condyle path.

Snow Face Bow.—The remaining data to be obtained is the *relation of the alveolar process of the maxillæ to the condyles.* This measurement is obtained by the Snow face bow, an invention of Dr. George B. Snow, Buffalo, N. Y. The instrument consists of a bow-shaped bar of metal with a sliding condyle bar at each end, and at the centre carrying a universal clamp and fork for holding the occlusion model. *A* and *B* are two forms of the fork or mouth piece (Fig. 67).

FIG. 67



Before attempting to use the face bow the outer tubercle of the condyle should be accurately located. By referring to the skull (Fig. 2, Chapter I), it will be seen that the glenoid fossa in which the condyle rests is just in front of the external auditory meatus, that it is enclosed by the auditory process at the back, the distal end of the zygoma

above, and the tubercle of the zygoma or eminentia articularis in front. This fossa may be located by pressing with the finger upon the face of the patient about one-half inch in front of the tragus of the ear, and at the same time requesting the patient to widely open the mouth. The outline of the depression or fossa should be accurately located. By again referring to Fig. 2 it will be seen that the crest of the tubercle of the condyle, when in the retruded position, is a little in front of the centre of the glenoid fossa. As the mouth is closed the tubercle of the condyle may be easily felt in a

FIG. 68

spare patient, but with much difficulty in a very fleshy patient. However, the fossa can always be detected and the location of the tubercle of the condyle closely estimated. It may be well to mark the location of the tubercle of the condyle upon both sides of the face. This may be done with a very soft lead pencil or a small piece of court plaster.

Face Bow Technique.—The fork of the face bow is removed from the clamp and the prongs of the fork sufficiently warmed to permit of their being inserted into the body of the upper occlusion model. The tail of the fork should be in the

median line of the face and parallel with the imaginary extension of the occlusal surface of the model. A slight variation from the indicated location of the fork will be of no consequence as the universal joint will accommodate itself to this. Both occlusion models are adjusted in the mouth, and the patient instructed to hold them not hard, but firmly closed. The jam nuts of the condyle bars are loosened so that the bars may slide freely. The universal clamp is opened widely so that the bow and fork may be easily adjusted. Just before slipping the clamp over the tail of the fork, the patient should be instructed in the working of the clamp and requested to set the clamp when they are given the word. The clamp is slipped over the tail of the fork, then the operator takes his position directly back of the patient, holding in each hand an end of the bow. The condyle bars are adjusted upon the tubercles of the condyles as indicated by the marks upon the face. These condyle bars must have an equal pressure upon the face and be advanced an equal distance through the bow, which can be easily adjusted by aid of the grooves upon the sliding bars. The universal clamp should be adjusted without strain upon the bow and fork. The patient is then given the word to set up the clamp screw tightly. The operator may then release one of his hands and satisfy himself that the clamp is firmly set. The condyle bars should again be inspected to see that they are properly located and that the head of each bar is an equal distance from the bow. While the patient is firmly holding the occlusion models, the lips are parted and if the models are properly occluded as indicated by the median and four buccal lines, the models may be securely united by inserting a four-pronged staple upon each side. The condyle bars are drawn away from the face, the mouth opened and the united models attached to the face bow removed.

Résumé and Observation.—The object of this chapter has been to differentiate between the wax-bite and the occlusion and contour models; also to teach their use and how to construct them.

It should be observed that the wax-bite (often called the quash-bite) is very limited in its usefulness, that it is very inadequate for any purpose except as location guides for partial cases. The quash-bite used for constructing complete artificial dentures belongs to that class of short-cut procedures essayed by charlatans and ignorant persons. No operator with an intelligent conception of the anatomy and physics of mastication can place any confidence in such methods. It is true that the quash-bite has been very largely used in the past and is too much used today, nevertheless it is an empirical method, and can never be associated with successful prosthesis.

It is apparent that the occlusion and contour models are the scientific and only practical method of gaining the necessary data for constructing useful artificial dentures; also that measuring instruments are necessary for obtaining data that can be acquired in no other way. In preceding sections of this chapter the Snow face bow for obtaining the relation of the alveolar processes of the maxillæ to the condyle, and the bite gauges, for recording two points in the movement of the condyle in its path, have been presented.

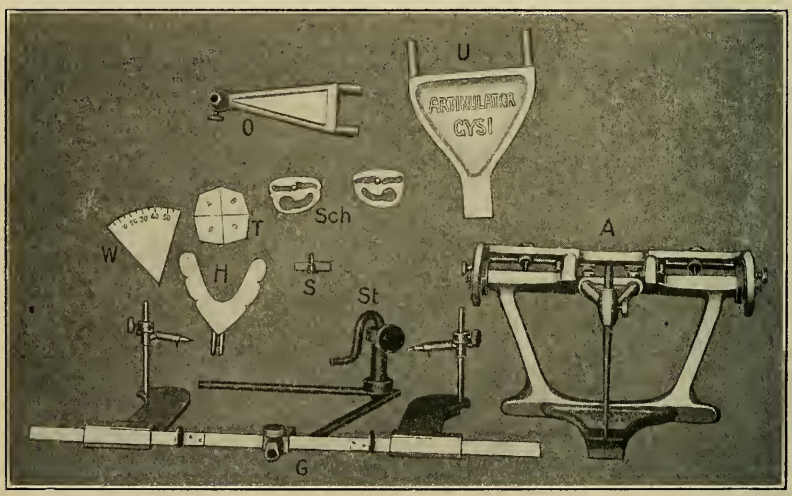
These instruments with a few obsolete ones are all that have been presented to the profession prior to the year 1910. While the Snow methods have been much in advance of other methods there were still measurements and means for their application desired. It has long been known that the pivotal centre of the temporomandibular articulation in the open and shut movement was not upon the head of the condyle, but somewhere below the head. (The Kerr "Articulator" was constructed upon this fact.) It is not believed that this pivotal centre has any appreciable effect upon artificial dentures. However, there is a lateral rotary movement of this temporomandibular articulation that very much influences the stability of artificial dentures if long cusp teeth are used. The Walker-Christensen-Snow method treated the condyle path as a straight oblique line, thereby only approximating the true condition. Excellent

results can be secured with measurements thus far obtained; however, we should always strive for perfection and adopt improved instruments and methods.

GYSI MEASURING INSTRUMENTS

Prof. Alfred Gys, of Zurich, Switzerland, gives a very lucid description of his instruments for measuring the condyle path, the retruded position of the condyle and the rotation points of the condyles, beginning with the January, 1910, number of the *Dental Cosmos*.

FIG. 69



A, articulator; *O*, *U*, extra bows; *G*, condyle path register; *H*, horseshoe plate; *Sch*, extra pair of condyle path guides; *W*, angle measure for condyle path slant; *T*, type plate for molar groove; S, small register; *St*, holder for register *G* (to be used when plastering models to articulator).

The following quotations and illustrations are from this remarkable article by Prof. Gysi:

"According to Bonwill, the two condyles form an equi-

lateral triangle with the contact point of the lower central incisors. I have therefore constructed two measuring instruments: With the one (Fig. 69, *G*), I determine, from the forward and opening movements and the combination of these two, the form and direction of the two condyle points of the triangle in a vertical plane; with the other instrument (Fig. 69, *S*), I determine, from the lateral movements, the path of the incisor point of the triangle in a horizontal plane.

"From the registered paths of these three points of the triangle in their separate directions, I can direct the movement of the mandible in all the combinations of the masticatory movements.

"**The Large Register for Determining the Slant of the Condyle Path.**—This instrument (Fig. 69, *G*) serves to measure the path taken by the condyles in the movements of the mandible. The important part of this instrument consists of two lead pencils, which in every individual case can be placed in the region of the condyles (Fig. 70).

"Its attachment to the mandible is accomplished through the horseshoe plate (Fig. 69, *H*), which, with its points on the under side, is pressed into the lower wax model which has been used in taking the bite (Fig. 70). The whole is so well balanced and weighted that it will, without any further help, remain firmly in its position in the mouth.

"Parallel to the horseshoe plate (which we shall consider as being in place) on the wax model and on a line with the plane of occlusion, parallel plates run backward on both sides (Fig. 70, *P*), carrying movable spring lead pencils in the region of the joint (Fig. 70, *B*). For extreme cases these lead pencil holders may be changed from the left to the right side, or moved up and down on their vertical bars with a screw (Fig. 69), so that the pencil points form as nearly as possible a right angle to the writing surface of the recording card (Fig. 70). The parallel plates with the lead pencils may be adjusted for individual cases by moving the cross-bar which holds them (Fig. 70, *T*).

"This instrument also serves as a compass, like the

American Snow face bow, which fixes the distance of the plaster models in correct relation to the axis of the joints.

"In order to find out the movements of the mandible in different individuals, the wax-bite plates are prepared in the usual manner, except that the base plates must be either of modelling compound 1.5 mm. in thickness, or of some other equally firm material reënforced in the usual way with a piece of wire. After proper attention has been paid to all the details, such as securing the proper fulness of the wax models to insure proper lip contour, the right height of the plane of occlusion, the length of the incisors, the median line of the face, etc., the patient is directed to open and close the mouth several times, during which positions of the condyles are ascertained by feeling in the region of the ear where they move. Then the positions of the condyles in the resting position (with the mouth closed) are found, and marked on the surface of the skin of the patient with a pencil or with chalk. Usually the condyles are found about one centimeter in front of the tragus of the ear, in the direction of the outside corner of the eye (Fig. 71). The horseshoe plate is then fastened by its points to the lower wax-bite plate and both are placed in the mouth.

"If some natural teeth are left in the mandible, a horseshoe plate without points can be used. Some hot modelling compound is placed on the under side of this plate and pressed over the teeth, just as though an impression were to be taken. In most cases where there are natural teeth, it is not absolutely necessary to measure the relations of the joints.

"The condyle path register is now attached to the horseshoe plate, which in its position in the mouth is firmly fixed to the wax-bite plate. The lead pencils are put at the marked places which indicate the positions of the condyles; by adjusting them on their perpendicular bars and through the sliding arrangement on the cross-bar, they are brought close to the surface of the skin.

"The form and slant of the condyle path will then be found by inserting a piece of cardboard, as shown in Fig. 70,

between the pencil points and the skin in the region of the joint, with the lower edge parallel to the parallel plates of the register. The latter plates are again moved on the cross-bar until the pencils are brought in such close contact to the writing surface of the card that the springs holding the lead

FIG. 70

Shows the method of determining the slant and form of the condyle path.

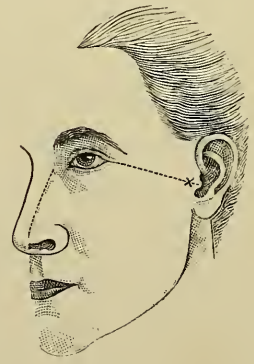
pencils are under a pressure. The patient is directed to move the mandible up and down, and from side to side (chiefly the latter motion), until the condyle path is clearly drawn on the surface of the recording card (Fig. 70).

"The lateral movements of the mandible show that the

curve first made by the opening and closing movements is followed in the lateral movements, and that while one condyle moves forward, the other moves more or less backward (see explanation to Fig. 77). The measuring of this moving path of the mandible occupies hardly three minutes' time.

"After one side of the mandible has thus been measured, the same card is held on the other side, and the same procedure is again followed. After the measuring is finished, the lead pencils are moved outward by the sliding arrangement on the cross-bar, so that the recording card and the register may be taken away, without, however, removing

FIG. 71

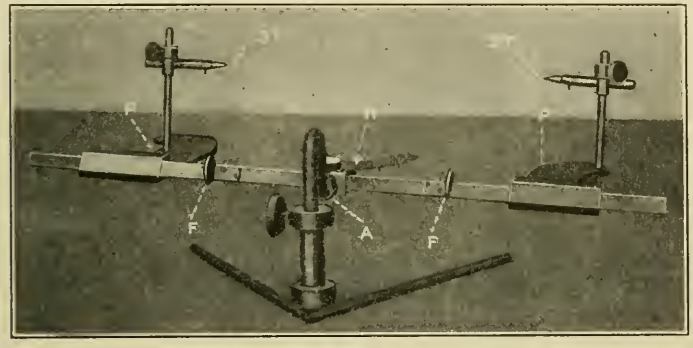


the horseshoe plate. The lead pencils with their holders must not be moved or turned on their vertical bars, as their position is of importance in attaching the models to the articulator, as we shall see later. The wax models may then be taken from the mouth.

"To find the angle of the registered path in relation to the occlusal plane, a slotted plate is selected which corresponds as nearly as possible to the form of the registered path. The plate chosen is placed directly over the lead pencil drawing, so that the drawn line can be seen approximately parallel to the sides of one of the slots (Fig. 73). Press the

point of the axis of the slotted plate through the card, and then mark the points of the long axis of the plate with a pencil. This will show the main direction of the path. The slotted plate is taken away, and both marked points are joined by a

FIG. 72



Shows the condyle register with the horseshoe plate attached, to which the lower wax-bite plate is fastened; *ST*, spring lead pencils; *P*, parallel plates; *H*, horseshoe plate; *F*, finger rests; *A*, place for inserting holder.

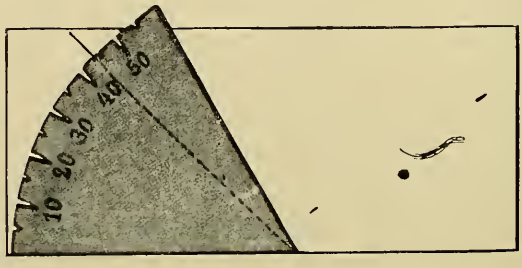
FIG. 73

Shows how the main direction of the condyle path is found by means of the slotted plate.

direct line (Fig. 73, left), which line is continued to the lower border of the card, so that with the angle measure one can determine (Fig. 74) the acute angle which this line forms with the lower border of the card. As this lower border of the card is held (in the registering of the path of

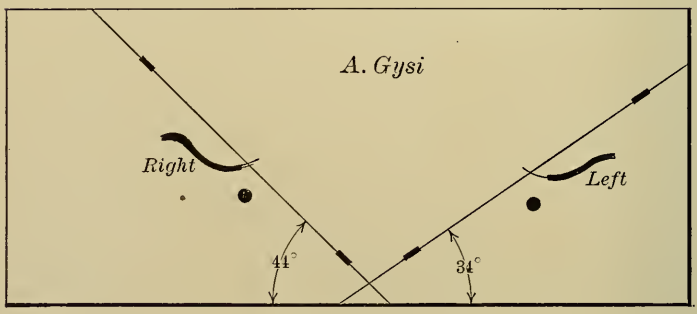
the condyles) parallel with the parallel plates, which in turn are parallel to the horseshoe plate, and this latter lies in the plane of occlusion, the angle measured in this way must correspond exactly with the slant of the path of the condyle to the plane of occlusion.

FIG. 74



Shows the mode of measuring the angle formed by the condyle path and the lower border of the recording card.

FIG. 75



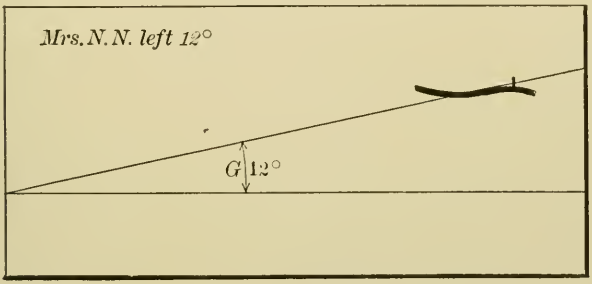
Shows the completed measurements of the condyle path.

"The slotted plate chosen is then placed in position on the articulator and the known slant fixed by means of the engraved degree scale on the joint of the instrument. Then proceed in the same manner with the registered condyle path of the other side.

"Fig. 75 shows a recording card with the registered condyle paths of the right and left sides, which have been measured in the manner stated. On the right side the condyle moves in a slant, the angle of which is 44 degrees to the plane of occlusion (Fig. 70, *P*); on the left the measured angle registers 34 degrees.

"In cases where the curve is more or less horizontal, and the lengthened line does not reach the lower border of the card, a line is drawn from the side of the card tangent to the lengthened line and parallel to the lower border of the card (Fig. 76).

Fig. 76



"The objection may be raised to my method of measuring that the plane of occlusion represented by the wax-bite plate is not a fixed point, because in setting up the artificial teeth one is obliged to change this temporary plane of occlusion according to circumstances.

"This objection, however, is only apparently justified, because in reality not only the angle of the condyle path to the temporary plane of occlusion is obtained, but also at the same time that to the alveolar ridge, or to the mandible itself as a whole.

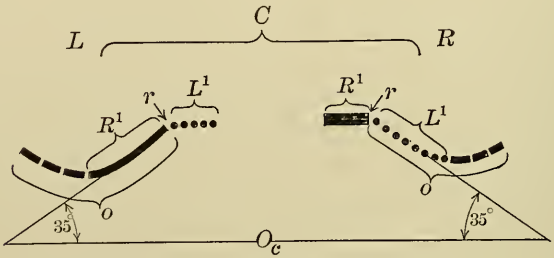
"If the temporary plane of occlusion is changed, the degree of the angle of the condyle path is of course also changed to agree with the new plane of occlusion, but the relative relations of the position of the mandible itself to the condyle path remain just the same.

"I will now give an analysis in detail of a condyle path curve as illustrated in Figs. 73 and 75.

"Fig. 77 shows an enlarged diagram of a left and right condyle path curve, each of which is divided into its chief parts, as indicated by the different lines.

"From the description of this diagram it can be seen that during the forward and downward movement of the one condyle, the other runs more or less backward horizontally.

FIG. 77



Analysis of a right and left condyle path as secured by method shown in Fig. 70: *C*, condyle path; *L*, left; *R*, right; *Oc*, plane of occlusion; 35 degrees, angle of middle part of path to plane of occlusion; *r*, resting position of condyle; R^1, path of condyle in a right lateral movement; L^1, the same in a left lateral movement; *o*, forward bite or wide opening and closing movement.

"The extreme forward movement and the opening and closing movements may be divided into two parts: First, the path which the condyle takes in a slight lateral movement, and second, the path which the condyle takes in its movement on the eminentia articularis, which is more or less horizontal and finally may even lead upward.

"As the last part of the path as represented by dashes in Fig. 77 can only occur in extreme lateral or wide opening movements, and is of no importance in mastication, I determine only the degree of the angle of the more important middle part of the curve to the plane of occlusion. (In the case represented in Fig. 77 the angle registers 35 degrees.)

"It does not often happen that both condyle path curves have the same form and slant. Some examples of the

differences in form and slant between left and right condyle path curves in the same individual may be seen in Fig. 80, *a* to *i*. The specimens in the same figure from *m* to *q* show that other differences may occur, either in only one or in both joints at the same time, between the path of the opening movement and the path of the lateral movement (*n* to *q*). For practical purposes only the path taken in the lateral movement possesses any value in the setting up of the artificial teeth for effective mastication, and therefore only this angle is measured.

"In Fig. 78 I have compiled a number of condyle path angles, and from these statistics it can be seen that the average angle is about 33 degrees.

EXAMPLES OF ANGLES OF THE CONDYLE PATH

(Same cases individually arranged)

Right	Left	Difference	Right	Left	Difference
54°	54°	0°	33°	38°	5°
40°	40°	0°	43°	38°	5°
33°	33°	0°	35°	30°	5°
51°	50°	1°	30°	25°	5°
26°	27°	1°	26°	20°	6°
39°	37°	2°	28°	20°	8°
28°	30°	2°	21°	13°	8°
23°	21°	2°	40°	32°	8°
35°	37°	2°	10°	19°	9°
40°	42°	2°	34°	25°	9°
32°	35°	3°	22°	31°	9°
31°	34°	3°	30°	40°	10°
33°	36°	3°	28°	39°	11°
37°	40°	3°	40°	25°	15°
5°	9°	4°	29°	45°	16°
36°	40°	4°	46°	29°	17°
10°	14°	4°	23°	45°	22°

"The accompanying table shows the same cases individually arranged, and it may be seen from it that in about half the cases there is a difference of only about 4 degrees

between the right and the left side. As this slight difference might be attributed to a possible mistake in measuring, it can be truly said that half the cases which I have measured had the same condyle path angle on both sides, and the other half showed a difference of between 5 and 22 degrees, averaging about 10 degrees. One astonishing case of exception showed 51 degrees on the right side and 10 degrees on the left, a difference of 41 degrees.

FIG. 78

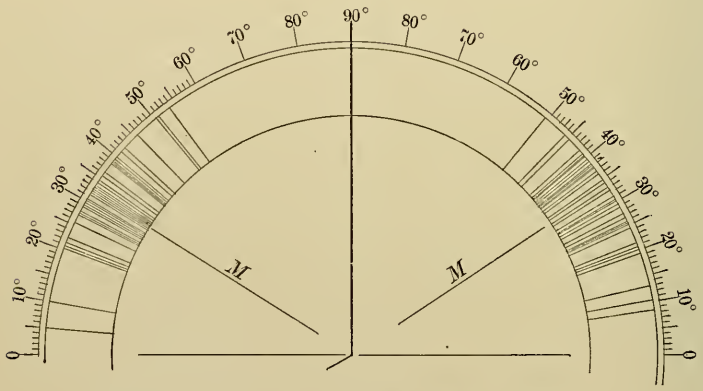


Diagram of a number of condyle path angles. (See table.)

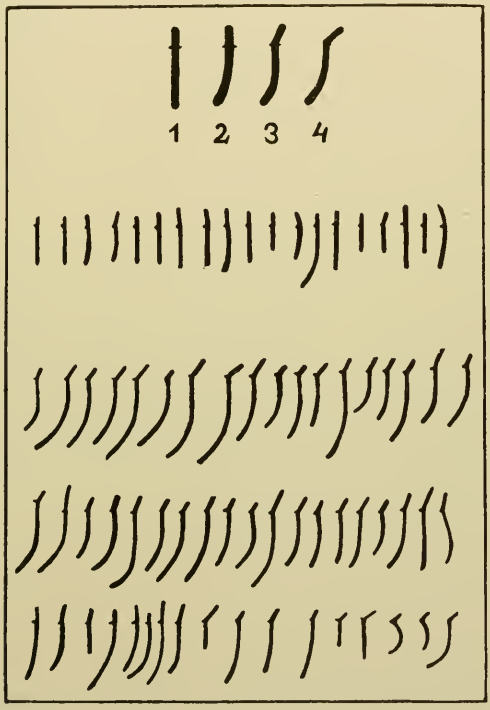
"Fig. 79 shows a collection of condyle path forms, from which I have chosen the four average types that are used in my articulator in the form of the slotted plates represented in Fig. 73. If necessary, other forms may be made from thin brass plate. These slotted plates are the condyle path guides of the articulator.

"The Small Register: Instrument for Determining the Path of Motion of the Anterior Triangle Point in a Horizontal Plane.— The movement of this point in a vertical plane in the opening and closing movement has, as has already been stated in the opening chapter, been measured by Tomes and Dolamore, but for practical purposes that has no value. Only the path in a horizontal plane, which varies from case to case, need be

determined for our purposes, as this alone has an influence on the setting-up of artificial teeth.

"To secure this, I proceed as follows: The shaded part of the horseshoe plate, as shown in Fig. 82, is covered with a

FIG. 79



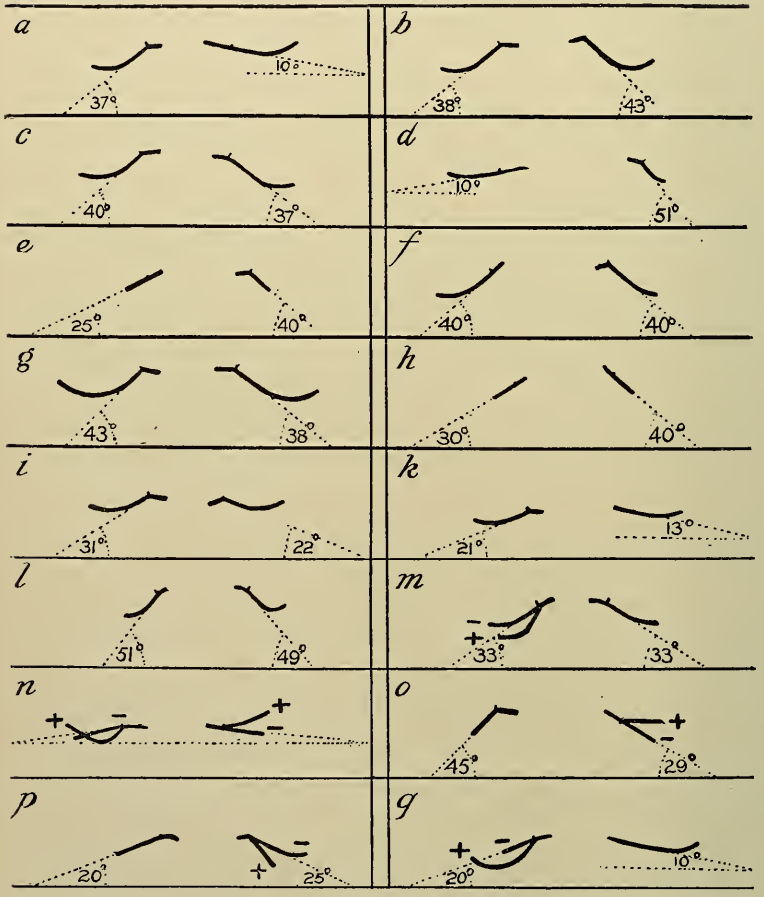
The four average forms of condyle paths. Examples of condyle path forms as registered in edentulous patients.

thin film of dark-colored wax, which with a hot instrument is spread to the thinness of paper.

"A pointed marker (the small register) mounted on a spring is now pressed directly over the median line of the upper wax model after having been warmed slightly, and

with a hot instrument is firmly attached at the edges. The point must stand out about one millimeter over the occluding surface of the wax model (Fig. 81).

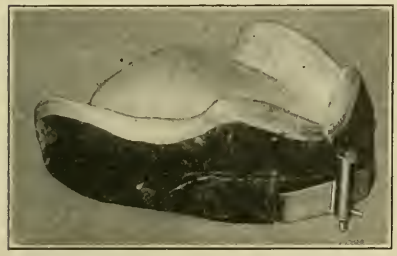
FIG. 80



"The upper and lower wax models are again placed in the mouth and held in position by a little tragacanth powder, and

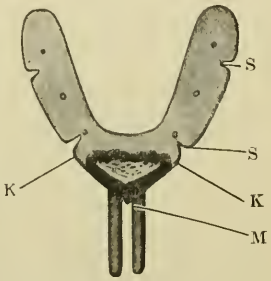
the patient is requested to move the mandible from side to side. The point of the marker registers these movements on the coating of wax on the horseshoe plate. At first these recorded movements are somewhat irregular and intertwine at the posterior portion of the wax-covered part of the plate (Fig. 82, *K*), because in the beginning the patient pushes the mandible too far forward. Without an effort to correct this improper position of the mandible, this movement is allowed to continue, and it will be seen that the mandible, owing to fatigue, will gradually go back to its normal distal position, and its path will be recorded by a correct regular curve (*K M K*).

FIG. 81



The small register fastened to the upper wax model.

FIG. 82



Horseshoe plate with registered incisor path.

"The outer line of these tangled markings is the normal path, the middle is the true median line and also the normal closing point in the resting (occlusal) position of the mandible.

"When the point of the marker is at *M*, Fig. 82, or in resting position (Fig. 83), the usual marks are made on both wax models at the notches prepared in the horseshoe plate (Fig. 82, *S S*) to show the proper position of the models when being fastened with plaster to the articulator.

"This instrument is of great service in the use of any articulator, because, leaving aside its special purpose, which

will be explained later, it is an excellent help in securing the normal resting position of the mandible.

"From the angle KMK the relative position of the balancing or rotation points of the mandible can be determined (see Fig. 84).

FIG. 83

Registering the incisor path.

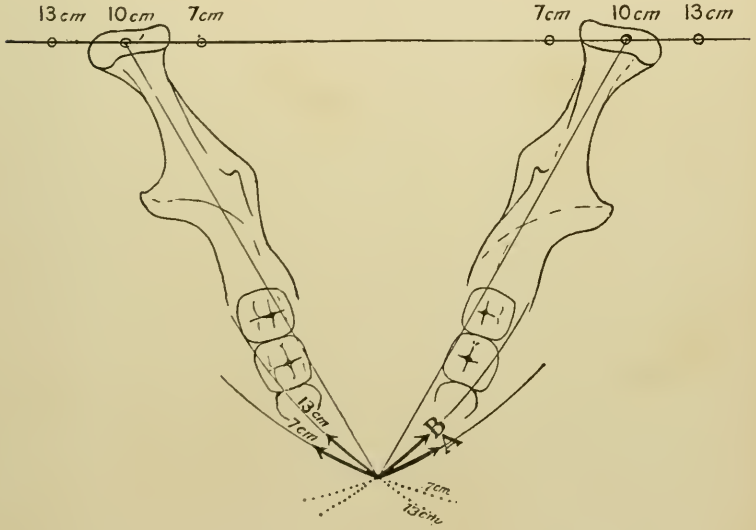
"If both sides of this angle are extended beyond the intersecting point (see dotted lines in Fig. 84), the direction of the path of the lower incisors and canines during mastication is shown.

"This angle of the incisor path varies in different individuals, and therefore the centre of rotation varies correspondingly. In my investigations I have found that the

relative distances between these rotation points may vary from 7 to 13 cm. measured by a line drawn through the centre of the condyles.

"In some cases these rotation points may lie still farther away from the condyles. As the average distance (according to Bonwill) between the condyle centres is 10 cm. the rotation points may lie sometimes inside and sometimes outside of the condyles. Very often the rotation point in the same individual may be differently situated on each side, *e. g.*, the one may lie inside, the other outside the condyle.

FIG. 84



"The importance of determining the exact position of these rotation points can be best understood by making a drawing like that in Fig. 84 on a triangular piece of cardboard, and recording the movements of the incisor point of the triangle by sticking a pin successively through the balancing points of 7, 10, and 13 cm., and with a sharp lead-pencil point inserted through the incisor point recording

the lateral movements. The result will show three different paths.

"Fig. 85 shows how both condyles carry out the same movement (in lateral movements) when the rotation points lie outside of the condyles 12 cm. apart, while the lead-pencil points attached to the large register will mark paths in the opposite direction.

"Fig. 86 shows how both the condyles and the lead-pencil points of the large register will record opposite paths in lateral movements when the rotation points lie inside the condyles.

"It is clear from these two illustrations that it is possible to determine the position of the rotation points from the relations of the paths (of the forward movement on the right sides and the backward movements on the left sides of Figs. 85 and 86) recorded by the registering instrument; but this method would not be accurate enough, owing to the short length of the paths, and therefore from even small mistakes in measuring great differences would arise.

"From the position of these rotation points it is plain that they could not be considered as anatomically fixed points, but rather as ideal balancing points, and for that reason their existence has remained unrecognized so long. Walker recognized their existence in 1896. (See *Dental Cosmos*, January, 1896, p. 34, and July, 1896, p. 573.)

"A balancing point is therefore the axis of rotation resulting from the diverse contractions of the masticatory muscles, and happens to coincide only now and then with the condyles. As it is impossible to imitate the muscles of mastication on an articulator, these balancing points must be substituted by mechanical centres of rotation, the positions of which can be changed from case to case.

"The natural condyles cannot be considered as true rotation points or axes around which the various movements of the mandible occur, but should only be regarded as fixed guides of the mandible in its movements.

"It is therefore not necessary to try to imitate the natural condyles nor the glenoid fossa on an articulator, but it is necessary to imitate the muscle movements by constructing

FIG. 85

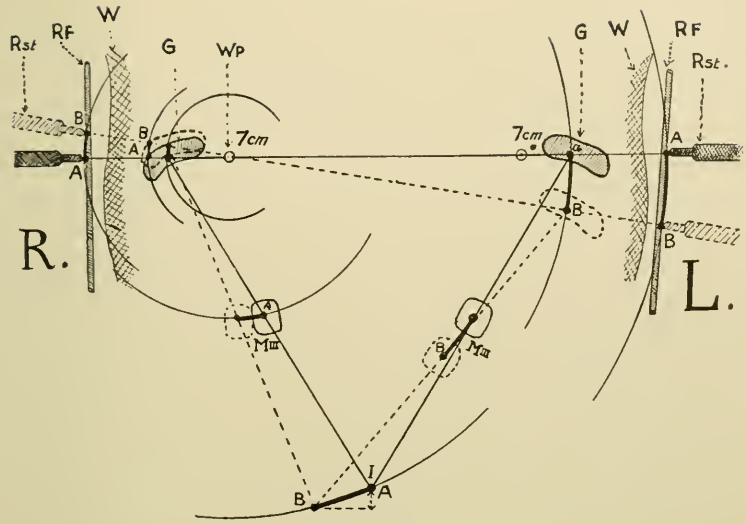
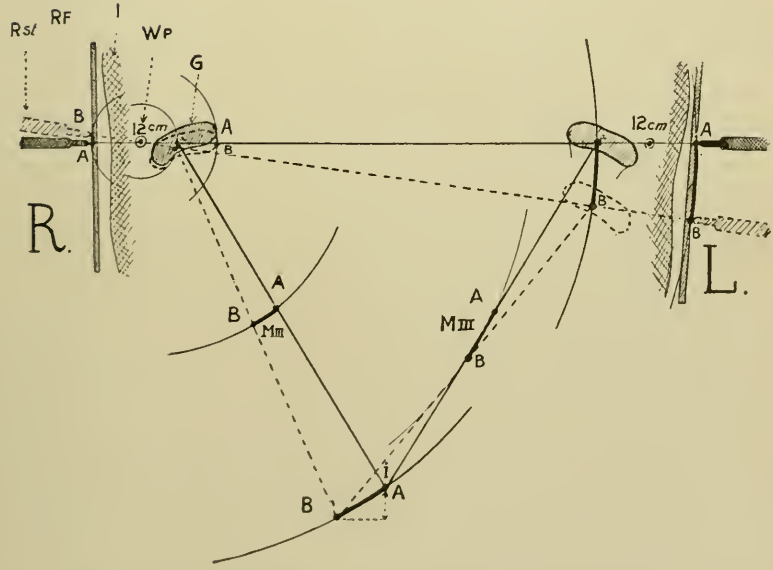


FIG. 86



Figs. 85 and 86: *R St*, registering point; *R F*, registering surface; *W*, soft parts over the joint; *Wp*, balancing point; *G*, condyle; *A*, *B*, moving path of the chief points of the mandible and of the registering points in lateral movements.

mechanical centres of rotation (as already stated) and mechanical condyle path guides, as represented in my articulator by slotted plates.

"The importance of knowing the relative position of the balancing points is made clear in Figs. 87 and 88.

"These balancing points can be constructed either geometrically with compass and rule, or simply by drawing on a piece of cardboard an equilateral triangle with sides of about 13 cm. in length, on which the outline of the mandible is drawn, with the teeth as in Figs. 87 and 88. Attach with wax small graphite points between the central incisors, also over the canines and over the middle of each molar. Grind these points to an equal height with a piece of sandpaper. Set the cardboard with the points downward on a piece of writing paper, insert a pin through the middle of each condyle, and make lateral masticating motions with the cardboard, when the graphite points will record their individual movements. If the same experiment is made with the pin inserted through the extreme balancing points of 7 and 13 cm. distance, quite different results will be obtained. These two-dimensional tracings as shown in Figs. 87 and 88 are not quite accurate; the angles would be slightly different in a normal natural case, where there is an overbite of incisors, and therefore a three-dimensional movement.

"In cases where the balancing points lie outside of the condyles, the mandible in lateral movements moves at the same time strongly forward. As the lower incisors are, however, somewhat hindered by the overbite of the upper incisors, the mandible glides downward and upward on the lingual surfaces of the upper incisors; consequently a longer overbite of the canines and higher cusps of the molars are necessary, in order that the teeth may not move too quickly away from each other.

"When, however, the positions of the balancing points lie inside of the condyles, the lower incisors move forward less obliquely and almost directly sideward, whereby for some distance the contact with the upper incisors is secured; consequently the overbite may be less and the cusps of the molars may be lower.

Fig. 87

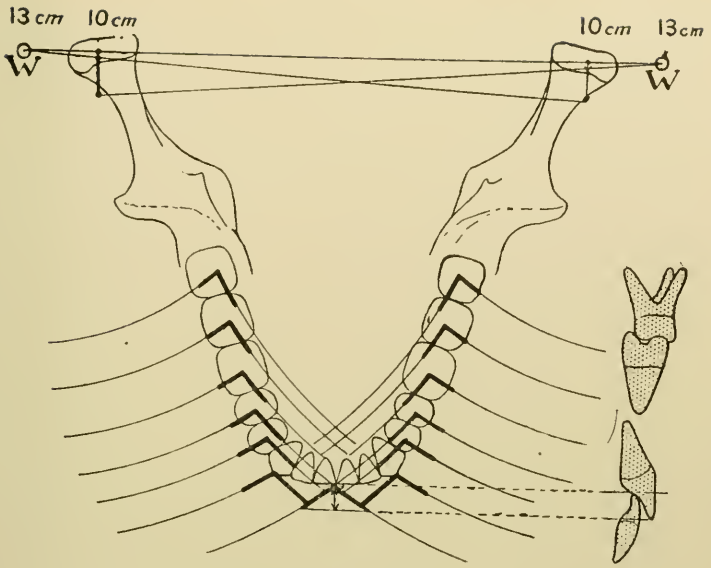
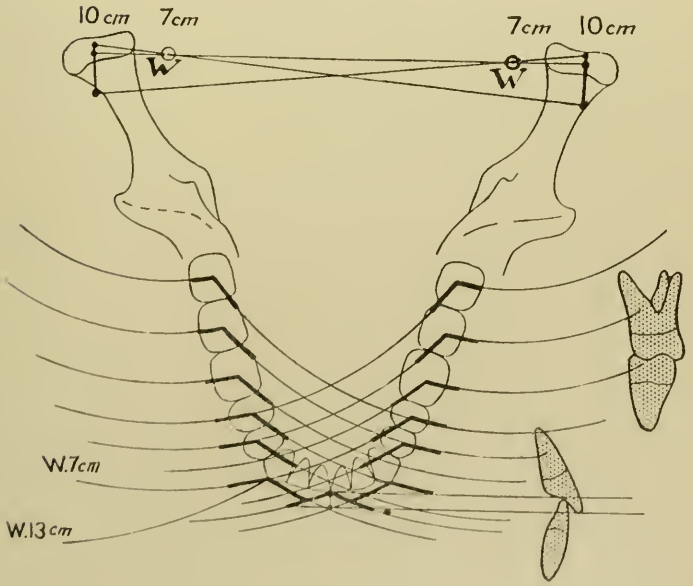
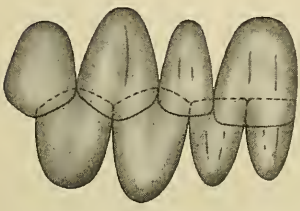


Fig. 88



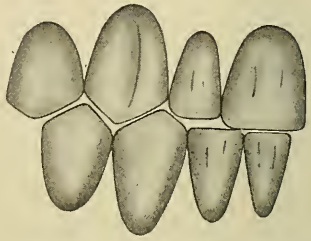
"The positions of the balancing points are still more important in regard to the relative positions of the upper and lower canines. To present this fact more clearly, the path of the canine in Fig. 87 is presented on the left side of Fig. 88, showing the difference in the paths of the lower canines according to whether the balancing point of 7 cm. or of 13 cm. asserts itself.

FIG. 89



Normal occlusion of artificial teeth.

FIG. 90



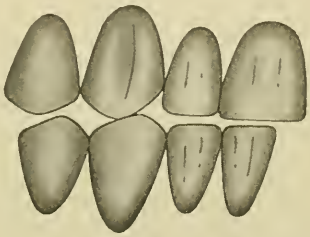
Normal position in a lateral movement when the correct balancing point has been secured.

"Fig. 89, for example, shows a side view of the canines in the normal occlusion as they are usually set up in an articulator for a practical case. Fig. 90 shows the same in a lateral movement. If, however, the patient has a different balancing point, the canines will describe another path, and the upper canine will not pass properly through the space between the lower bicuspid and canine, but will rather strike against the cusp of the latter, thus forming the only contact point of the tooth rows, and thereby tilting and loosening the upper plate (see Fig. 91). With such an artificial denture lateral movements are absolutely impossible, and the patient in eating is compelled to carry on only up-and-down movements, or else ultimately the cusps of the canines as well as those of the bicuspids must be ground off, whereby the natural appearance and the usefulness of the denture is destroyed.

"As I have already stated, the mandible cannot make a free lateral movement, being partly prevented by the overbite of the upper incisors. Therefore the lateral movements

are combined with the opening and closing movements. If no overbite were present, the front teeth in the lateral bite would, after a short grinding movement, glide away from each other, and the whole force of the masticatory muscles would rest on the molars exclusively, so that the latter would be worn away altogether too quickly. These conditions may be noted in the ruminants (horses, cows, etc.); the increased wearing away of the molars is, however, compensated by their numerous and deep enamel folds.

FIG. 91



Incorrect position in a lateral movement when the balancing point of the articulator differs from the natural one.

"The upper incisors, because of their slanting surfaces on the lingual side, have the important function of acting as the anterior guiding and gliding plane of the mandible, while the condyles and the eminentia articularis act as guides of the posterior movements of the mandible. These latter guiding planes of the two posterior points of the triangle have a slant of from 5 to 50 degrees, while the anterior point of the triangle or incisor guide exhibits a slant of from 50 to 70 degrees to the occlusal plane.

"In edentulous patients it has been impossible so far to determine the previous guide angle of the incisor. I believe, however, that this represents a racial phenomenon, directly dependent upon the facial angle. From a small number of measurements I have found that the angle of the slant of the lingual surfaces of the incisors, which form the incisor guide, amounts to 15 degrees less than the facial angle formed by a line connecting the outer ear with the base of

the nose, and a line connecting the most prominent part of the forehead with the base of the nose. These measurements are, however, too small in number and too superficial to serve as full proofs.

"If the angle of the guiding surfaces of the incisors is determined in such an arbitrary way, it is of no practical value in an artificial denture. For practical reasons, which will be discussed in a subsequent chapter, I nearly always choose the lowest angle, of about 45 degrees or less, for this gliding angle of the incisors.

"From all these considerations it follows unquestionably that in lateral movements the centres of rotation or balancing points lie approximately on a line passing through the centre of the condyle region, and that these balancing points in different individuals may lie either on the inside or the outside of the condyles.

"As I shall show later, the mandible in opening and closing rotates around another centre, which, however, has no influence in the setting up of the teeth for articulation, and therefore need not be considered in the construction of an articulator. In the Walker articulator this opening axis can be attached, and is used when the plane of articulation is to be lowered or raised. In the Kerr articulator the true axis of rotation on opening is permanently fixed on the articulator. In my articulator the ordinary axis for opening and closing movements is used—as it has no influence on the slant of the condyle path—in the same way as in Walker's and Christensen's articulator.

"From these observations it follows that in the construction of an articulator the following points should be considered:

"1. An individually changeable slant of the condyle path.

"2. An individually changeable form of the condyle path.

"3. A changeable incisor guide.

"4. Two individually changeable balancing or rotation points.

"5. The incisor guide must not change the slant of the condyle path; the slant of the condyle path must, therefore, be independent of the opening movement."

CHAPTER V

ARTICULATORS AND ANTAGONIZORS

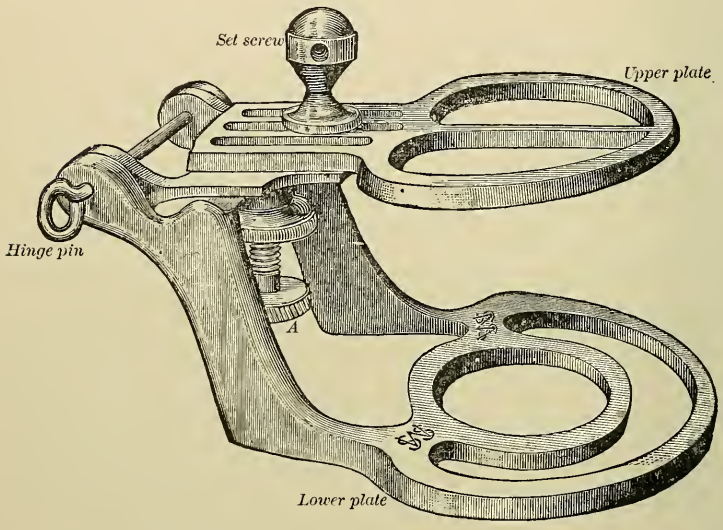
Definition.—Articulator is a name applied to apparatus of many designs. Of these many designs it may truly be said that a few are good, that a few others are bad, but that the most of them are indifferent. Unfortunately the name is a misnomer, but it is so universally used that it seems a useless expenditure of time to more than explain the anomaly. The term is used in the anatomical sense, and means "a joint," hence the instrument can only rightly be termed an articulator because of its hinge joint, not because of the operation for which it is designed. The instrument is used to assemble artificial teeth in occlusion, and they should be in antagonization. The operation for which the instrument is intended is to occlude and antagonize the teeth and not to articulate the teeth, as is usually stated, for teeth, both natural and artificial, can articulate only upon their proximate mesial and distal surfaces; but not upon their occlusal surfaces. The name "articulation" for assemblage of the teeth is a misnomer, therefore it is absurd to name the instrument in conformity with the misnamed operation.

Under the general term "articulator" two distinct types of instruments are included, the simple hinge joint class called *articulator* (Fig. 92), and the class which make a pretence of imitating the temporomandibular articulation called *anatomical articulator*. Hereafter in this book when the hinge-joint type is referred to it will be called *occlusion frame*, and when the other type is meant it will be called the *antagonizor*.

Occlusion Frame.—An occlusion frame is a dentist's apparatus to secure the open and shut arrangement of artificial teeth.

Antagonizor.—An antagonizor is a dentist's apparatus to secure anatomical and mechanical arrangement of artificial teeth.

FIG. 92



History.—Guerini gives credit for the original invention of this device to J. B. Gariot about 1805. Many forms of the apparatus have since been devised, a few of which are of historical interest because they denote professional thought and endeavor.

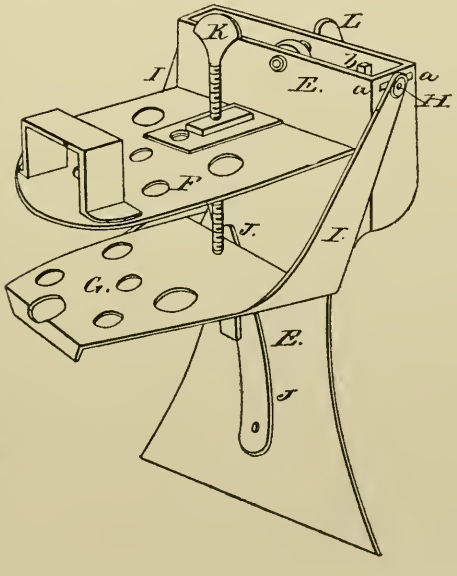
August 28, 1840, Daniel T. Evans, of Philadelphia, obtained a patent for an apparatus having slot and pin joints, by means of which, as he expressed it in his specifications, "the lower plate is allowed a motion at the joints similar to that which is admitted by the condyloid processes of the living subject" (Fig. 93).

In 1858 Dr. W. G. A. Bonwill, of Philadelphia, invented his instrument. He presented the instrument and his studies of anatomical antagonization before the American Dental Association at Niagara Falls, N. Y., in 1864. Dr.

Bonwill may be justly called the father of anatomical antagonization and antagonizors because of the volume of research work and writing he did upon the subject. Undoubtedly his genius has inspired all later work in this field of endeavor (Fig. 94).

In 1889 Dr. Richmond S. Hayes, of East Bloomfield, N. Y., received a patent for an antagonizor which embodied at

Fig. 93

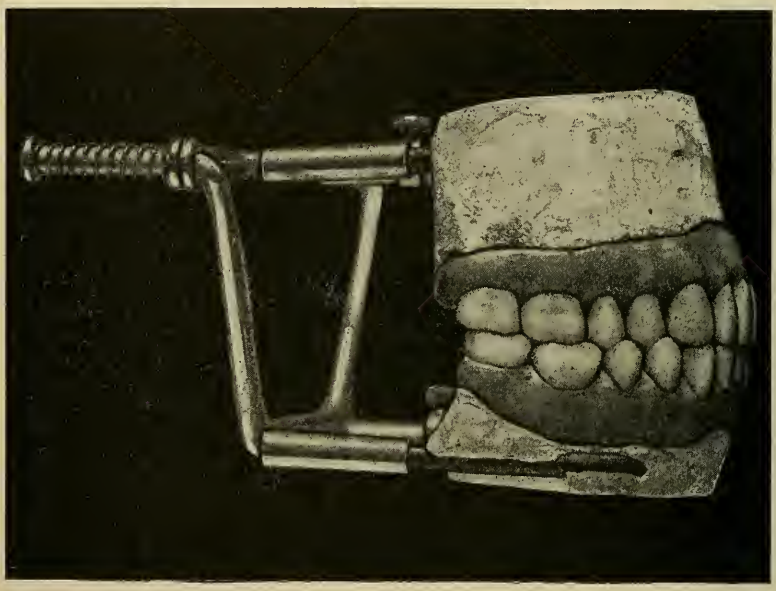


least one new feature. He probably was the first to attempt to reproduce the downward motion of the condyle. Prof. Gysi says, speaking of the "forward and downward slope": "This fact had previously been noted by two anatomists—Luce, of Boston (1889), and Count Spee (1890)—but their work remained unknown to dentists for some years." It

will be noticed that the earlier date given by Prof. Gysi is the same as of the patent paper of Dr. Hayes.

The Walker antagonizor (Fig. 95): Dr. George B. Snow, of Buffalo, in his paper published in the *Dentist's Magazine*, July, 1907, says: "In 1896 Dr. W. E. Walker, then of Pass Christian, Miss., now of New Orleans, obtained a patent upon an antagonizor constructed in much the same manner as the

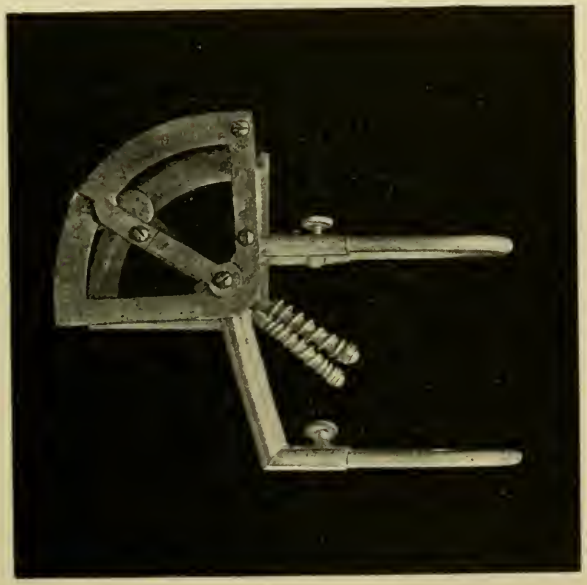
FIG. 94



Bonwill, but with adjustable joints for imitating the direction of the condyle path. Dr. Walker is the first one who clearly recognized the fact that there was a considerable variation in the inclination of movements of the condyle upon the eminentia articularis. He obtained another patent upon an instrument by which the inclination of the condyle path could be ascertained. This he called a 'facial clinometer.' But he also lost sight of the second condition of the problem,

the correct location of the casts in the antagonizor. Dr. Walker made a close study of his subject, and his papers, published in the *Cosmos* for 1896 and 1897, are well worth reading. They are, in fact, nearly exhaustive so far as they go, and he is entitled to great credit, much more than he has received for their presentation."

Fig. 95



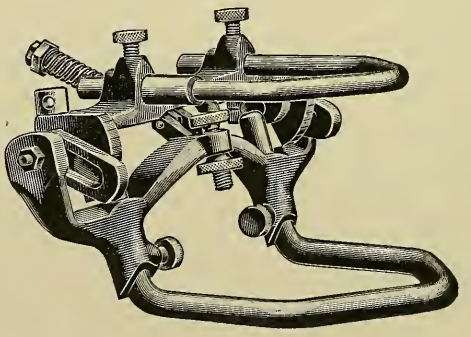
In 1899 Dr. A. De Witt Gritman, then of Buffalo, but now of Philadelphia, and Dr. George B. Snow introduced the Gritman antagonizor and the Snow face bow.

In 1901, in *Ash's Quarterly*, and the *Cosmos* for October, 1905, Prof. Carl Christenson describes his antagonizor. In the paper previously referred to Dr. Snow says: "He (Prof. Christenson) showed at that time his simple and practical method of ascertaining the inclination of the condyle path, and transferring it to the antagonizor, thus taking the

last step necessary for the full solution of the problem of the correct antagonization of full dentures. But he did not recognize the importance of correctly locating the casts in the antagonizor, and in the one which he constructed, which much resembles that of Dr. Walker, he unfortunately designed it so that the casts cannot be placed near enough to the joints."

In the *Transactions of the Odontological Society of Great Britain,* 1903, J. B. Parfit described his antagonizor with its curved condyle path constructed for each case. This instrument required that the ascertained condyle path for each individual case be cut out of a sheet of metal and clamped to the jaw of the antagonizor.

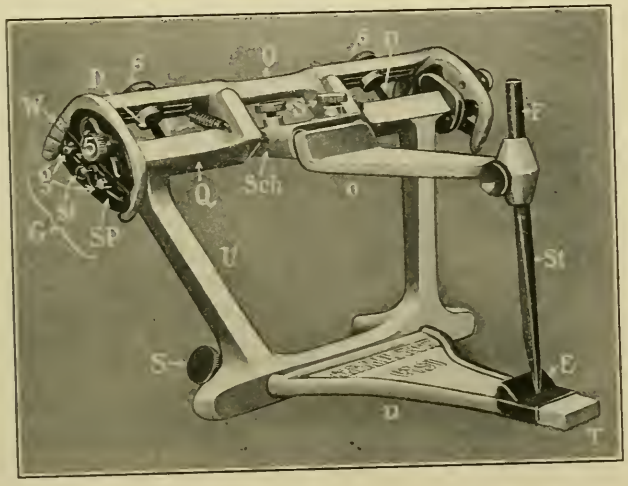
Fig. 96



In 1907 Dr. George B. Snow introduced the New Century Antagonizor (Fig. 96). This instrument is built upon the lines of the Gritman. The frame is higher arched and therefore more open at the back than its predecessor. It has each bow secured with two set screws. Beginning with January, 1911, the instrument is to be provided with an extra pair of bows, the lower of which will be extra long and the upper bayonet-shaped, thus accommodating any thickness of casts. The straight upper bow has a sleeve for marking its position, so that it may be removed and returned at will. The position of the lower bow is registered by the plaster

securing the lower cast. It has straight slotted adjustable condyle paths, and metal spuds for obtaining the inclination of the paths. The central spiral clamping spring is effectual and convenient. There is an extension of the slot pin for supporting the face bow. The face bow accessory of this instrument has been described (Chapter IV). It is a simple, well-constructed, and effectual instrument. It reproduces most of the essential movements of the mandible. It certainly has no equal save one, the elaborate instrument of Prof. Gysi.

FIG. 97



Gysi Antagonizor.—At the time of writing this chapter the author has had no practical experience with the Gysi instruments, but from the written description, and inspection of them, he is confident the new instruments offer great possibilities for the prosthetist. The following is Prof. Gysi's description of the antagonizor as presented in the February, 1910, *Dental Cosmos:*

"This antagonizor (Fig. 69, *A*, and Fig. 97), like all others, consists of a movable upper part (Fig. 97, *O*) and a fixed lower part, *U*. To the upper part the bayonet-

shaped bow, *o*, is attached and secured by screws, *S*. An extra straight bow (Fig. 69) can be inserted if preferable. To the lower part a straight bow is attached and secured by screws, *S*. An extra bow (Fig. 69, *U*) can be attached having a base that is $1\frac{1}{2}$ cm. higher. With these four bows six different combinations can be effected to correspond to the height of the plaster casts, thus saving much time in their preparation for the antagonizor. The bows should be oiled and pushed as far into the antagonizor as they will go, so that should it be necessary for any reason to remove them together with the casts from the antagonizor, they can be easily and accurately placed in their former positions.

"To the upper bow an adjustable supporting pin, *St*, is attached, which rests on the narrow end of the small plate, *T*, of the lower bow. On this narrow end of the lower bow is attached an inclined plane, *E*, on which the supporting pin moves upward in the side movements. The supporting pin should always rest at the foot of this inclined plane. This inclined plane forms the incisor guide, and serves on the antagonizor as a substitute for the overbite. Up to the present time the artificial incisors, attached with wax to the trial plates, have taken the place of this incisor guide. This was a most uncertain guide, especially in warm weather. For practical reasons, which will not be further discussed, this inclined plane is attached to the lower part of the antagonizor instead of to the upper part, just as all antagonizors have a fixed lower and a movable upper part, entirely contrary to the natural relations, but, as is well known, answering the same purpose.

"As the supporting pin acts as a guide to the height of the bite, it is placed in front of the incisors, because it is only here that a true and secure support can be obtained. If this supporting pin interferes with the setting up of the incisors, it can be removed until the latter are placed in position.

"File marks (Fig. 97, *F*) can be made on the supporting pin, so that there is at all times a guide to show that the

height of the bite has not been changed in the setting up of the teeth.

"The placing of this supporting pin in front of the incisors offers the further advantage that the antagonizor is quite unobstructed at the back, so that the lingual surfaces of the teeth are clearly visible and can easily be reached with the fingers and wax spatula. This is important, in that it permits of the correct antagonization of the lingual surfaces of the teeth.

"The most important function of this supporting pin and the inclined plane consists in the prevention of the wrong downward movement of the upper part of the antagonizor produced in all antagonizors up to this time when reproducing lateral movements.

"The upper bow, *o*, is connected with the upper part of the antagonizor by a hinge joint, so that in the setting up of the artificial teeth opening and closing movements can be made that are independent of the true joint movement; consequently the two condyle parts of the triangle can be combined exactly and precisely with the incisive part of the triangle in such a way that all unnatural movements are impossible. In this manner the downward movement of the mandible combines with the forward movement in the direct forward and lateral movements. This combined movement, which has long been recognized, is for the first time accurately reproduced by the antagonizor.

"The upper and lower parts of the antagonizor are connected through the real joint, *G*, which permits of the lateral movements. Two springs, *F*, automatically bring the two parts back to their normal positions.

"The joint is formed by the fork, *g*, of the lower part of the antagonizor, the prongs of which pass through the E-shaped part of the upper half and receive the slotted plate, *Sp*. The fork *g* rotates and with the slotted plate can be fixed by the screw, 5, at an angle of from 0 to 50 degrees.

"The two identical slots in the slotted plate which receive the prongs of the fork *g* correspond in form to the path which the condyles take in their movement during mastication.

"To be quite exact, a number of different forms of slotted plates should be kept. From my long experience, however I have found that the two average forms are quite sufficient, and if the artificial teeth are placed in the exact position necessary to secure the full value of the gradations of these two condyle path forms, the result is most satisfactory. If a special form for every case is thought necessary, as advocated by Campion and Parfitt, it can be easily and quickly sawed out of thin brass plate and placed on the antagonizor.

"The pin, *st*, found on the slotted plate serves to bring the latter into its proper place, and should always be placed in the hole provided for it in the middle of the E-shaped joint.

"In order to change the slotted plate, the binding screw, 5, is first loosened, then the prongs of the fork *g* are turned to a vertical position, which will allow the plate to slide over the head of the binding screw. With the prongs in the same position another plate can be put on and fixed at the desired angle. This is accomplished by placing the index of the slotted plate at the required degree on the engraved scale, *W*, in the E-shaped joint.

"The two small supporting pins, *D D*, at the back, with the large supporting pin, *St*, form a secure triangle which is not to be found in any other antagonizor. This, together with the solid cast pieces, prevents any looseness or any springiness, and thus insures the possibility of true and exact work.

"The small supporting pins, *D D*, in the slotted upper part, *O*, can be moved sideways. They rest on the transverse piece of the lower part, on which is an engraved scale to indicate the positions of the pins. As the positions of these supporting pins are determined by the incisor path these scales are only of value when two or more full upper and lower dentures are to be made at the same time, when the different positions of these pins can be noted on the plaster casts. For unmeasured cases and partial dentures the pins are placed at the average position of 10 cm., forming a

Bonwill triangle with the average distance of 10 cm. between the condyles.

"The rear supporting pins form the true balancing or rotation points in the lateral movements of the mandible. They can lie from 7 to 13 cm. apart, and even more, in spite of the fact that the condyles in adults on an average seldom lie farther apart than 10 cm. These balancing points, as stated before, do not exist anatomically, but are the result of the various muscle contractions that move the mandible, and are its true rotation points during lateral masticatory movements.

"When in trying in dentures it is found that the antagonization is not correct in lateral movements (which cannot occur, if my incisor register is used) a correction can easily be made by attaching a piece of cardboard or thin metal plate with wax under one of the supporting pins until the proper antagonizing position is secured, when the teeth can be re-antagonized.

"When the antagonization is faulty because the mandible has been pushed too far forward in taking the bite, it is corrected in the same manner as in other antagonizors, by drawing out the upper bow to the distance necessary for correction.

"With the rear supporting pins placed at the average position of 10 cm. and the slant of the condyle path fixed at the average angle of 30 degrees, the antagonizor will be found of great value for all partial dentures, bridges, and even for single crowns; because, when the natural lateral movements are reproduced, the proper height of the cusps can be accurately determined, and porcelain facings can be so placed that the liability to breakage because of improper occlusion or antagonization will be reduced to a minimum.

"For small casts the high-base bow (Fig. 69 *U*,) can be used, together with the inverted bayonet-shaped bow, making the space between the bows so small that thick plaster foundations will not be necessary.

"The great value of this antagonizor consists in the fact that complete upper and lower dentures can be made in

exact conformity to the individual relations of the joints, and that when the average positions of both scales are used it is an anatomically perfect, stable, and handy antagonizor for all partial dentures, crowns, and bridges.

"When the antagonizor is used without the help of the measuring instruments, it is important to place all casts so that the occlusal plane is exactly parallel to the table on which the antagonizor stands, as the degree scales are founded on a corresponding horizontal plane. It is also important to have the front of the casts at an equal distance of 10 cm. from the rear supporting pins, thus forming a Bonwill triangle."

MOUNTING

How Mounted.—The two types of instruments under consideration are for distinct operations. The antagonizors may be used as an occlusion frame, but the occlusion frame cannot be used as an antagonizor. The operation of occlusion is a simple one, while that of antagonization is complex, and includes occlusion as one of its factors.

The occlusion frames are designed to hold the plaster casts in a fixed position, but for convenience of mounting the teeth upon either cast, the other should be removed sufficiently to give finger room for manipulation; hence, the instrument is provided with a hinge-joint, thus permitting removal without loss of relationship. As the instrument is designed to hold the casts in a fixed position, it can make no difference in what position the casts are mounted in the frames, so long as the position is convenient for manipulation. Usually the incisor section of the casts are placed at the front, but in some partial cases it may convenience the workman to place the bicuspid section to the front; the relationship of the casts, however, will be the same.

The antagonizors being designed to hold the casts and mounted teeth in many positions, it is necessary that the casts shall be definitely and accurately located, therefore specific instruction is required for occlusion frames as a

class, and each antagonizor; however, of the antagonizors the Snow and Gysi only will be further considered.

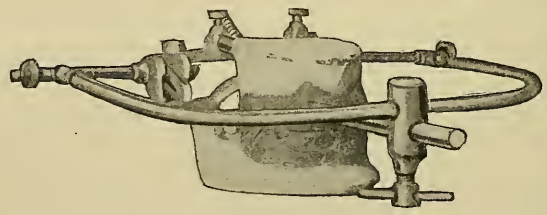
Mounting upon Occlusion Frames.—The plaster casts and wax-bite, or occlusion and contour models, as may be had, are assembled and united with a little melted wax. These are placed upon the lower part of the occlusion frame, the upper part is adjusted with the set screw so that it will be just free of the upper cast, and the set screw is fixed with the jam nut (Fig. 92). The casts are united to the frame with a soft mix of plaster; however, if the plaster casts have been standing a few hours so as to become dry, they should be saturated with water just before mixing the attaching plaster. Some of the soft mixed plaster is placed upon a slightly oiled surface; any convenient substance, as glass, marble, metal, or wood, or a piece of paper, may be placed upon the work bench, and the plaster placed upon it. The occlusion frame containing the casts is placed on the soft plaster and firmly pressed into place. The upper portion of the occlusion frame is raised, soft plaster placed upon the upper cast, and the raised portion of the frame pressed firmly into it. The soft plaster may be smoothed by trowelling with the plaster spatula (Fig. 27). If the casts have been made unnecessarily thick it may be necessary to trim them down, otherwise it may be difficult to adjust them in the occlusion frames.

Mounting upon the Snow Antagonizor.—The antagonizor is prepared for the case by adjusting the set screw and making firm its jam nut, so that the bows are parallel to each other. The bows are then adjusted to give the necessary space to insert the assembled casts and models. This is accomplished by sliding the lower bow either up or down and using either the straight or bayonet-shaped upper bow, as may be required to accommodate the case. The lower cast should be so trimmed that the occlusal surfaces of the wax models shall be parallel with the bows. The case being mounted without the face bow, the assembled casts and models should be centrally located, with the portion representing the mesial incisal angle of the lower central incisor

teeth four inches from either condyle joint. The assemblage is then united with plaster as described for occlusion frames.

Mounting with the Face Bow.—The set screw with its jam nut having been fixed as described in the preceding paragraph, the assembled casts, occlusion and contour models, and face bow, as described in Chapter IV, are ready for mounting in the antagonizor. The condyle bars of the face bow are pushed in to their limit and made fast with their jam nuts. The head of each condyle bar has a depression which fits over the extended slot pin. The heads of the condyle bars are adjusted to the antagonizor by springing the face bow sufficient to permit the heads to slip over the slot pins. The lower cast rests on the lower bow; however, the cast must not be attached to the lower bow until the occlusal surface

Fig. 98



of the occlusion model is parallel with the horizontal portion of the lower bow. This relationship of cast and bow may be secured either by trimming the cast (which is rarely necessary), or by pushing in or pulling out the lower bow. The lower bow being adjusted, it is secured with its set screws. Either the straight or bayonet-shaped upper bow is adjusted as may be necessary to clear the upper cast. The casts are then made fast to the bows with plaster as previously described (Fig. 98). The plaster luting having thoroughly hardened, the face bow is removed. The remaining step is to secure the inclination of the condyle path. Loosen the condyle clamps so the slotted condyle bars may move freely, unhook the spiral spring, readjust the bite gauges. (See Chapter IV.) The bite gauges being adjusted in both wax

models and the incised portion of the wax models in contact, the slotted condyle bars must assume their respective positions, when they are firmly clamped (Fig. 99). The bite gauges are removed and the spiral spring attached (Fig. 100).

Fig. 99

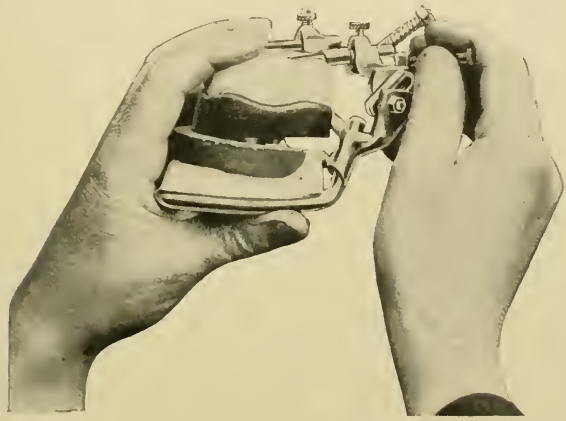
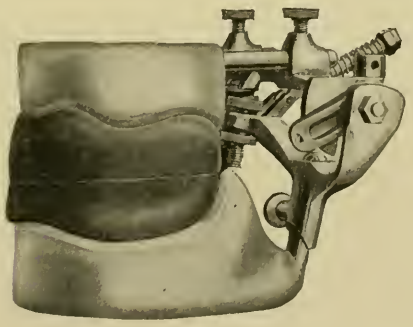


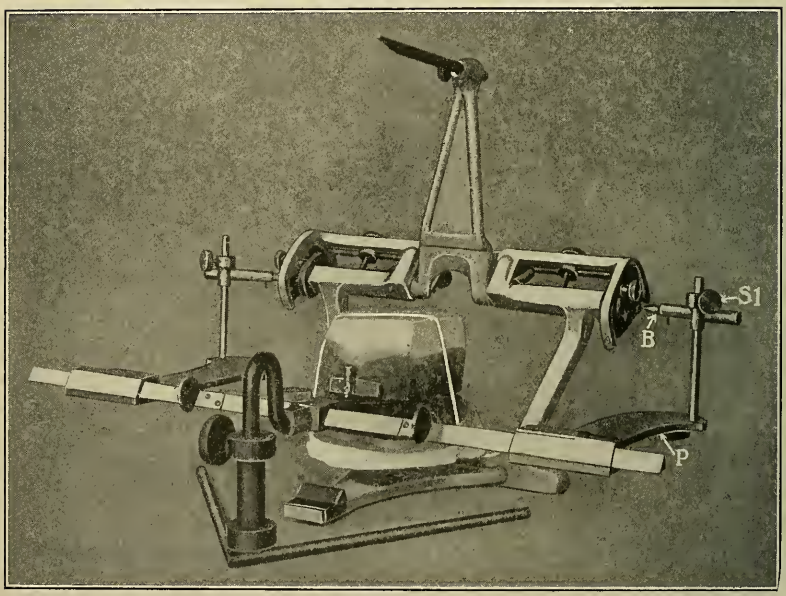
Fig. 100



Mounting upon the Gysi Antagonizor.—"When the wax models have been constructed and the relations of the joints have been secured the wax models are placed on their respective casts. The latter are then placed in correct relation to

each other by means of the marks on the wax models, without removing the horseshoe plate. After it has been ascertained that the point of the small register rests exactly in the centre of the recording wax surface of the horseshoe plate, it is pushed up and turned into its resting-place so that it may not separate the models owing to its spring. The models can be slightly fastened with a little hot wax, and held

Fig. 101



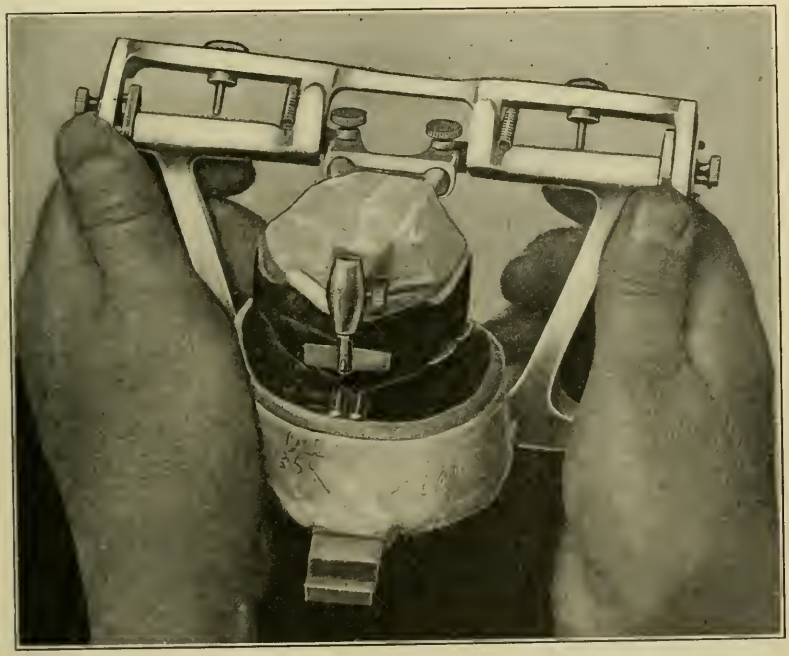
together temporarily with a rubber band. The large register is then attached to the horseshoe plate, and with the aid of the holder (Fig. 69, *St*) the whole is placed in position as shown in Fig. 101. When the graphite points of the large register are placed exactly at the axis of the fork *g*, Fig. 97, the casts are in correct relation to the joint.

"The plaster casts must be cut until they will go into the proper positions. This is important in case it is found

necessary, after trying in the teeth, to raise or lower the height of the bite.

"When the casts have been attached the large register may be taken away, leaving the horseshoe plate in its place. The slotted plates presenting the condyle paths are placed in position and set at the desired angle.

Fig. 102

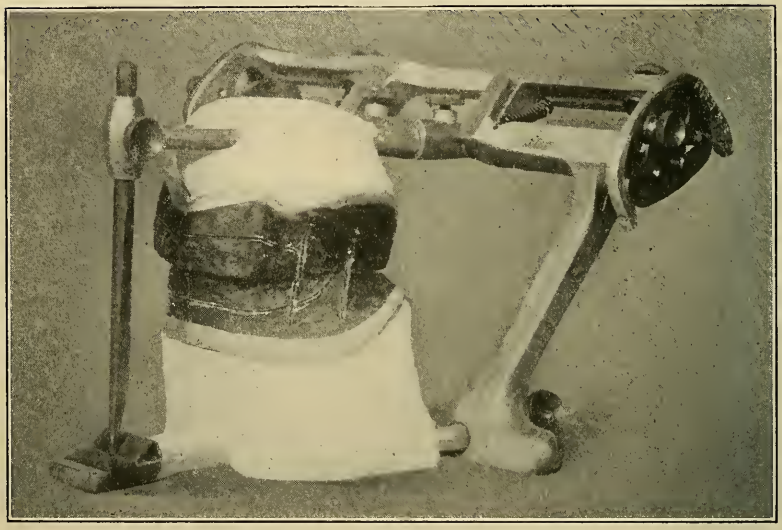


"Lateral movements are then made and the rear supporting pins are adjusted so that the point of the small register follows the angle *K M K*, Fig. 82, on the horseshoe plate. In this manner the true balancing points of the mandible are determined and fixed on the antagonizor (Fig. 102).

"The front supporting pin is then placed in position with

the point at the foot of the inclined plane, thus fixing the height of the bite. The horseshoe plate is taken away,

Fig. 103



some wax being added to the lower model to fill in the space that had been occupied by the plate. The small register is also taken away (Fig. 103)."

CHAPTER VI

RUBBER AND VULCANITE[1]

Rubber.—India rubber or caoutchouc.

Vulcanite.—A chemical compound of caoutchouc and sulphur.

CAOUTCHOUC

History.—Caoutchouc is a native Indian name. India rubber is a name given the material because its early use in Europe was to remove black lead pencil marks from paper. Dr. Priestley, the distinguished discoverer of oxygen, mentions this use in a publication of 1770. Caoutchouc must have been known in America at a very early period, because balls made from the gum of a tree, lighter and bounding better than the wind-balls of Castile, are mentioned by Herrera when speaking of the amusements of the natives of Haiti, in his account of the second voyage of Columbus. In a book published in Madrid, 1615, Juan de Torquemada mentions a tree which yields it in Mexico, describes the mode of collecting the gum, and states that it was made into shoes. More exact information was furnished by a French Academician, who visited South America in 1735. While the Indians used it more than three hundred years ago for water bottles and gum shoes, it was only used in the United States and Europe for erasing pencil marks, until about 1820, when it was applied to waterproofing cloth. As caoutchouc became hard and brittle in cold weather and sticky in hot weather, many experiments were

[1] The history, physical and chemical properties of rubber and vulcanite are taken from the Author's chapter in Turner's American Text-Book of Prosthetic Dentistry.

made to overcome this objectionable quality, which resulted in the discovery of vulcanite in 1843.

Physical Properties.—Caoutchouc is the dried milky juice of various trees and plants. A similar gum capable of vulcanization can be obtained from the common milkweed and other plants of temperate climates, but it is only commercially profitable from certain trees in the tropics. The Brazilian, or Para (a shipping port on the Amazon river) caoutchouc is the product of several species of Siphonia (nat. ord. Euphorbiaceæ), chiefly Siphonia elastica. Bates says that this tree is not remarkable in appearance; in bark and foliage it is not unlike the European Ash, but the trunk, like that of all forest trees, shoots up to an immense height before throwing off branches. The India rubber produced in New Granada, Ecuador, and Central America is obtained from Castilloa elastica; that of East India from the beautiful glossy-leaved Ficus elastica, now a common ornamental plant in conservatories; that of Borneo from Urceola elastica; and that of West Africa from several species of Landolphia and also Ficus.

After the trees are tapped, the juice is first received in clay basins, and then is solidified in various ways—as by spreading it out in thin layers and evaporating in the sun or by the aid of artificial heat; or the emulsion is coagulated by the leaves of a kind of vine—a method used in Central America—which gives, however, a product inferior to that obtained by evaporation. The evaporated product is known as "biscuit." The fresh juice has the consistency of cream, is yellow, miscible with water, but not with naphtha or other solvents of ordinary rubber; its specific gravity is 1.02 to to 1.41; the yield of the gum is about 30 per cent. Pure caoutchouc is devoid of odor and is nearly white; it has the specific gravity of 0.915. The finest quality of caoutchouc is that from Brazil (Para), which has the least impurities; the other South and Central American kinds are of medium quality; East India rubber ranks next, while the African rubber is quite inferior.

Commercial India rubber is a dark, tough, fibrous substance, possessing elastic properties in the highest degree. At the freezing point of water it hardens and largely loses its elasticity. The gum is insoluble in water or alcohol, and is not acted upon by alkalies or acids except when the latter are concentrated and heat is applied. It is soluble in ether, chloroform, bisulphide of carbon, naphtha, petroleum, benzol, and the essential oils, and in many of the fixed oils by the aid of heat. Caoutchouc melts at a temperature of 250° F. and does not again resume its former elastic state; at 600° F. it volatilizes and undergoes decomposition.

Purifying.—In the manufacture of India-rubber the first operation is the purification of the crude material. The impure rubber is cut into minute shreds and is washed by powerful machinery immersed in water, which releases the solid impurities. The washed gum is then placed on iron trays and dried in a room heated by steam. The material then undergoes a process of kneading under very heavy rollers, which causes the adhesion of its various pieces to each other and ultimately yields a mass or block of India rubber so compact that all air-holes, other cells, and interstices disappear.

Chemistry of Caoutchouc.[1]—India rubber, as is well-known, is the product of the coagulation of the milky juice of a large number of trees, creepers, and shrubs. The commercial article can hardly be expected to be homogeneous, and still less a pure product in the chemical sense. Besides accidental impurities of sand and fragments, it contains a greater or less amount of oily and resinous matter, which varies greatly even in the same brand of rubber. Para rubber contains from 1 to 2 per cent.; Logus rubber from 3 to 7 per cent.; Borneo rubber from 6 to 21 per cent.; and African Flake may contain as high as 64 per cent. Lascelles-Scott gives the composition of a brand of unnamed origin:

[1] The writer uses as his authority for this paragraph and the subsequent ones upon the Chemistry of Vulcanite, "The Chemistry of India Rubber," by Carl Otto Weber, Ph.D., published by Charles Griffin & Co., Limited, London; J. B. Lippincott Company, Philadelphia, 1903.

	Per cent.
India rubber (gum)	37.13
Albumin	2.71
Resins	3.44
Essential oils	Traces.
Sugar	4.17
Mineral matter	0.23
Water	52.32

The pure Para gum consists of soluble and insoluble portions, the latter averaging about 3.5 per cent. The soluble portion has a formula of $C_{10}H_{16}$, and is the portion with which the sulphur combines to form vulcanite. The formula for the insoluble portion is $C_{30}H_{68}O_{10}$.

VULCANITE

History.—Charles Goodyear,[1] of New Haven, Conn., discovered the process of curing or vulcanizing India rubber in 1843. Thomas Hancock, of England, has been credited with making this discovery contemporaneously; but his own writings state that he had seen small samples of Goodyear's work, and that after much experimenting, he produced the same thing; so the priority of the discovery undoubtedly belongs to Goodyear.

On January 30, 1844, a patent was granted to Charles Goodyear for making soft or flexible rubber that would resist the action of the usual solvents of caoutchouc, and would not be affected by cold or heat if the temperature were not raised above the vulcanizing point. The mixture he preferred was caoutchouc, 25 parts; sulphur, 5 parts; and white lead, 7 parts. This produced soft vulcanite.

The process of making hard rubber was patented by Nelson Goodyear May 6, 1851. His formula consisted of one-half pound of sulphur to a pound of caoutchouc and one-half pound of any one of a long list of earthy substances.

[1] This historical sketch of vulcanite is made up largely from the monograph, "Instructions in Vulcanite," by Prof. E. Wildman, M.D., D.D.S., Philadelphia, Samuel S. White, 1867.

A patent was granted to Charles Goodyear, Jr., "For improvement in plates for artificial teeth," dated March 4, 1855. He says: "The best compound I believe to be one pound of India rubber or gutta-percha (or of the two combined in suitable proportions) with a half pound of sulphur, together with a suitable quantity of coloring matter. To obtain a suitable color, I mix with caoutchouc or gutta-percha, vermilion, oxide of zinc, oxide of iron, or any coloring substance that will stand the necessary degree of heat with the action of sulphur. This compound, after having been molded, is subjected to heat for about six hours, and in so doing I gradually raise the heat to about 230° F., say in half an hour, and then, unless there be a considerable quantity of foreign matter present, the heat may be raised, quickly as may be, to about 295° F.; otherwise, I raise the heat more slowly and keep the compound at about that temperature for the remainder of the six hours, and then allow the whole to cool down, when the process will be completed."

A patent was granted in June, 1857, to H. H. Day for vulcanizing very thick pieces of rubber. To accomplish this, he mixes with the matter prepared for vulcanization a substance that will prevent its becoming spongy or cellular, by absorbing the sulphur gases as fast as generated. The material which he proposed to employ for this purpose is ordinary fire clay, but other substances capable of absorbing the gas may be employed.

In Austin G. Day's specification we find some interesting remarks upon the nature of rubber compounds. In contradistinction to Nelson Goodyear's hard and inflexible substance, he claims his compound to be a hard, but highly elastic material obtained by a process differing from that of N. Goodyear's in the length of time, in the degree of heat, in the proportion of the ingredients, and in the mode of equalizing the temperature.

Day's composition is one pound of purified Para rubber and one-half pound of sulphur.

He remarks: "In the vulcanizing process there is eliminated during the whole operation a constant discharge of

sulphuretted hydrogen and other sulphuretted gases, which must have means of escape through the pores of the mass while being vulcanized. By my present improved management of the heat in vulcanizing, by raising it very gradually, step by step, to the highest point, I am enabled to vulcanize pieces of an inch or more in thickness with great uniformity and perfection. A mixture containing earthy matter may be vulcanized in much shorter time than one consisting of caoutchouc and sulphur alone, and yet be solid, owing to the earthy matter facilitating the escape of the gases generated in its substance during the process. At the same time such compositions are destitute of elasticity and flexibility. For a piece five-eighths of an inch thick, the time required for vulcanizing is thirteen and one-half hours:

It is held at	275° F., for 6 hours.
Then raised to and held at	280° F., for 3 hours.
Then raised to and held at	290° F., for 2 hours.
Then raised to and held at	295° F., for 2 hours.
Then raised to and held at	300° F., for $\frac{1}{2}$ hour.

Composition of Vulcanite for Artificial Dentures.—As the formulæ of the various makes of rubber are "trade secrets" of the manufacturers, our knowledge is limited to the general specifications of patent papers and the writings which detail the experiments of Prof. Wildman and others.

Both the soft pliable and the hard flexible vulcanite are used in the construction of dentures. The essential components of vulcanite are caoutchouc and sulphur, the ratio varying according to the use for which the product is designed. All other ingredients are for coloring or to cheapen the product.

The soft pliable variety used in dentistry is known as velum rubber, because its most important use is for vela for cleft palates. It contains sulphur to the extent of about one-fifth of the weight of the gum. Hard vulcanite, sometimes called ebonite, contains by weight one-half as much sulphur as caoutchouc.

Some of the formulas given by Prof. Wildman are:

DARK BROWN

Caoutchouc	48 parts
Sulphur	24 parts

RED

Caoutchouc	48 parts
Sulphur	24 parts
Vermilion	36 parts

DARK PINK

Caoutchouc	48 parts
Sulphur	24 parts
White oxide of zinc	30 parts
Vermilion	10 parts

GRAYISH WHITE

Caoutchouc	48 parts
Sulphur	24 parts
White oxide of zinc	96 parts

BLACK

Caoutchouc	48 parts
Sulphur	24 parts
Ivory black or drop black	24 parts

JET BLACK

Caoutchouc	48 parts
Sulphur	24 parts
Ivory black or drop black	48 parts

If pure caoutchouc is burned, there should be but about 3 per cent. of dark ash remaining. Sulphur and vermilion (mercuric sulphide) leave no ash, hence the percentage of ash from rubber containing these materials should be less than 3 in the ratio of the amount of these materials to the caoutchouc. Some rubbers leave as high as 60 per cent. of ash. It would be reasonable to suppose that the strength would be reduced in ratio to the amount of the ash, but this is not true, as the pure gum and sulphur produce the strongest vulcanite; the red and black are nearly the same strength, although the black rubber will leave a much larger ash than red, because the coloring matter is animal charcoal composed largely of phosphate and carbonate of lime,

while the mercuric sulphide would be entirely volatilized. The oxide of zinc and other earthy matter in the pink and white rubbers have a very deleterious effect upon the flexibility and tenacity of the vulcanized rubber, so much, in fact, that these light colored vulcanites are not one-fourth as strong as the brown, red, or black.

Physical Properties of Vulcanite.—Vulcanite is hard, flexible, and horn-like in texture. Dr. George B. Snow gives the specific gravity of a specimen of black vulcanite as 1.1974, and that of the same piece before vulcanizing as 1.1333. The specific gravity varies, as it is much affected by the coloring matter, and is also increased by the temperature and time of vulcanization. Caoutchouc expands upon heating. Dr. Snow says: "Rubber expands by heat more rapidly than any other solid body. Its rate of expansion at ordinary temperatures, from 70° to 90° F. is over six times that of iron, about five times that of brass, and nearly four times that of zinc, which is the most susceptible to expansion by heat of any of the metals. Its rate of expansion is known to increase as the temperature rises, but it has not been definitely determined." In vulcanizing soon after chemical action begins (248° F.), expansion ceases and contraction commences, the latter being much affected by the contained foreign matter, by a high or low temperature, and by a long or short time of vulcanization. Its increased specific gravity is due to this contraction.

The usual solvents of caoutchouc have but little action upon vulcanite, and no agent which can be tolerated in the mouth has any action upon it. It is susceptible of a high polish. It is very opaque, and, therefore, does not imitate well the appearance of the mucous membrane. It is a very poor conductor of thermal and electrical changes, in consequence of which it is not conducive to the health of the tissues upon which it is worn. It is porous, although this condition is invisible to the eye. It absorbs the secretions of the mouth, even though the rubber has been perfectly vulcanized, and when improperly vulcanized it becomes so saturated with decomposing secretions that it is exceedingly

offensive. Great care should be used in vulcanizing rubber that is to be worn in the mouth, and the patient should be thoroughly instructed in cleansing it.

New rubber can be added to old vulcanite by reheating; hence vulcanite dentures can be easily repaired. It is unnecessary to add a solution of rubber to vulcanite to aid in its repair, as the solvent has no action upon the vulcanite, only leaving a thin layer of soft rubber to penetrate the pores of the vulcanite, a result better accomplished by heat and pressure.

Chemistry of Vulcanization.—Vulcanization consists of the chemical union of caoutchouc and sulphur, probably producing a series of compounds having the formula $C_{10}H_{16}S_2$ for the highest combination, and $C_{100}H_{160}S$ for the lowest, with a series from the lowest to the highest.

Vulcanization can be brought about either by the cold or the hot process, and by using with the latter either the dry or the wet method. The essential requisite is to secure the union of the sulphur with the polyprene ($C_{10}H_{16}$).

The cold process is by the use of sulphur monochloride, and is only suitable for very thin layers of rubber, being, therefore, not applicable for dental use. An attempt has been made to sell to the profession office rights for the use of a porcelain enamel for facing vulcanite dentures. This method was based upon the cold vulcanization process. While the results were an improvement upon ordinary pink rubber, the product lacked the translucent effect of fused porcelain, its durability was uncertain, and the process was long and tedious.

Mr. Weber in the work previously referred to, says: "We turn our attention first to the question of the general action of sulphur upon India rubber at high temperatures. The sulphur bath method might appear from several points of view the most suitable method of studying this question, but after a number of attempts I abandoned it in favor of the method of subjecting carefully prepared homogeneous mixtures of Para rubber with a definite amount of sulphur to the action of heat. Again in this case we have the choice

of several methods of heating, but the one of heating pieces of Para mixture of uniform thickness to vulcanizing temperatures when immersed in water appeared to me the most satisfactory, as it involves the minimum of loss of sulphur by evaporation.

"The experiments were carried on with strips cut from a calendered sheet, 3 mm. in thickness—a mixture of 100 parts of Para rubber with 10 parts of pure precipitated sulphur. These strips were vulcanized in a phosphor-bronze digester.

"The digester is provided with a thermometer tube (thermometer in mercury), a pressure gauge, and a blow-off valve. In the digester a porcelain beaker is suspended so that it is clear of the bottom. The digester is filled to about one-quarter of its capacity with water; the beaker is completely charged with water, and a number of the strips to be experimented upon immersed in it. The digester is then closed, rapidly heated to the required temperature, and maintained thereat, either by carefully adjusting the gas burner, or by means of some form of thermo-regulator. At regular intervals one of the strips is withdrawn after blowing off steam and rapidly opening the digester, which is then immediately closed again to continue the series. The time error caused by these successive withdrawals does not exceed four minutes per sample. Of course, the water lost by the blow-off steam is from time to time made up with boiling water.

"The strips thus withdrawn are marked, and subsequently cut into very fine threads, which are freed from every trace of uncombined sulphur by extraction with acetone in a Soxhlet extractor. The greatest care was employed to render this operation perfect, every sample being subjected to a three days' continuous extraction. The extracted samples were dried in a current of carbonic acid in the water oven, and, until analysis, were preserved in carefully stoppered glass tubes.

"About one gram of each of these samples was used for analysis. The sulphur determinations were all, without

exception, carried out by Carius' method, as the results by the much simpler and more expeditious method proposed by Henriques were found to be liable to an error approaching 0.1 per cent. in magnitude. In this manner the following results were obtained:

VULCANIZATION OF PARA RUBBER

Duration of vulcanization.	Temperature of vulcanization. 120° C. S.%	125° C. S.%	130° C. S.%	135° C. S.%	140° C. S.%
30 mins.	0.71	0.71	0.99	1.76	....
60 "	1.18	1.32	1.44	2.17	....
90 "	1.31	1.67	2.04	2.36	....
120 "	1.62	1.91	2.32	3.92	5.07
150 "	....	....	....	4.02	....
180 "	1.78	2.11	2.94	4.18	6.05
240 "	1.93	2.22	5.00	5.50	....
300 "	2.25	2.35	5.27	6.74	....
360 "	2.60	3.80	5.82	6.88	....
420 "	3.71	4.04	6.04	6.97	....
480 "	3.94	4.31	6.33	7.13	....

"These figures amply suffice to demonstrate indisputably the fact, even quite recently again denied, that the vulcanization of India rubber with sulphur involves the chemical combination of these two substances, at any rate so far as the vulcanization of Para rubber is concerned.

"That different brands of India rubber behave very differently in the vulcanization process is a well-known fact, but what we know at this moment respecting the composition and chemical relationship of these different brands entitles us to assume that, although their behavior under vulcanization may not be identical with the Para rubber, it will be more or less closely analogous to it."

Following this, Mr. Weber gives a tabulation of his experiments with Upper Congo, Beni River, Ceara, and Borneo rubber for the same duration of vulcanization and for 125° C. and 135° C. He then sums up these experiments thus:

"The extremely interesting results here tabulated remove all doubt that the vulcanization of India rubber is a chemical

process resulting in the formation of a polyprene sulphide. The rate at which the sulphur enters into combination with the India rubber hydrocarbon (polyprene) is characteristic for each brand of India rubber. Some of the above series were repeatedly investigated, always with the same result.

"There arises now, of course, at once the question as to the nature of the process by which sulphur enters into combination with the polyprene, whether the polyprene sulphide or sulphides formed are addition or substitution products. Certainly what we already know respecting the chemical nature of India-rubber, leads us to infer that the vulcanization process consists essentially in the formation of an addition product of sulphur and polyprene. This assumption, however, requires support in view of the fact that quite a number of writers, from Payen to most of the recent authors, declare that vulcanization is accompanied by the evolution of hydrogen sulphide, thereby implying that the process is a substitution, and not an addition process. Indeed, most of the recent authors on this subject state this in so many words. We, shall, therefore have to subject this point to a careful examination.

"Assuming the compound of polyprene and sulphur, which indisputably forms in the vulcanization process, to be a substitution product, it follows with absolute necessity that for each 32 parts of sulphur combining with the polyprene, we must obtain 34 parts of hydrogen sulphide. Now, in the process of vulcanization as practically carried out, we obtain on an average, a product containing, say, 2.5 per cent. of combined sulphur. Consequently the vulcanization of one ton of India rubber, on the above assumption, would be bound to yield very nearly 60 pounds of hydrogen sulphide, or approximately 18,000 liters. Considering that in a number of factories the amount of India rubber vulcanized daily largely exceeds one ton in weight, we should expect to find the vulcanizing rooms of these factories reeking with gas. As a matter of fact, however, there is scarcely ever a trace of this gas to be discovered in the rubber works' atmosphere, and the very rare cases in which

its presence becomes noticeable may always be considered as an indication of something having gone wrong.

"In the vulcanization of 'hard rubber' goods (ebonite vulcanite) faint but distinct traces of hydrogen sulphide are generally, perhaps always, observable, but they could not be ascribed to the vulcanization process proper—the combination of polyprene with sulphur—which process, if it consisted in the substitution of hydrogen for sulphur, should cause a perfectly torrential evolution of hydrogen sulphide, seeing that 'hard rubber' contains at least 20 per cent. of combined sulphur.

"It is, therefore, certain that if hydrogen sulphide forms at all in the vulcanizing process, its amount is utterly inadequate to support the assumption that the process of vulcanization is a substitution process.

"Laboratory experiments on this question lead to exactly the same conclusion. If the experiments are carried out with technically pure Para rubber under conditions absolutely precluding the escape of any gaseous product of the reaction, very minute traces of hydrogen sulphide may sometimes be observed; but in a considerable number of carefully devised experiments with highly purified Para rubber no hydrogen sulphide at all could be detected.

"If, on the other hand, the 'insoluble' part of India-rubber is mixed with sulphur, and this mixture is subjected to a vulcanizing temperature, say about 135° C., a considerable evolution of hydrogen sulphide takes place, due to the formation of a substitution product of this insoluble body, $C_{30}H_{68}O_{10}$, with sulphur. This substitution process certainly proceeds much slower than the vulcanization process of India rubber (polyprene). Under the same conditions of temperature and the time under which polyprene forms a vulcanization product containing 4 per cent. of sulphur, the above-named insoluble constituent forms a substitution product containing at most 0.7 per cent. of sulphur.

"From these facts we are justified in drawing the following conclusions:

"1. The India rubber hydrocarbon, polyprene $C_{10}H_{16}$, combines with sulphur without evolution of hydrogen sulphide. The vulcanization process of India rubber is, therefore, an addition process.

"2. The insoluble constituent of India-rubber, which forms only an insignificant proportion of the technical product, not exceeding 5 per cent. of the total, combines with sulphur under vulcanizing conditions at a very slow rate, with evolution of hydrogen sulphide and with the formation of a substitution product.

"The above conclusively settles the question regarding the general chemical aspect of the vulcanization process, but it confronts us with the further question respecting the quantity of sulphur combining with India-rubber in this process, as well as the more intimate structure of the compound thus formed."

Interesting and instructive as the work of Mr. Weber is, the limits of this chapter will not permit us to follow him in detail, but only to give his conclusions.

"The process of vulcanization consists in the formation of a continuous series of addition products of polyprene and sulphur, with probably a polyprene sulphide, $C_{100}H_{160}S$, as the lower, and $C_{100}H_{160}S_{20}$ as the upper limit of the series. Physically this series is characterized by the decrease of distensibility, and the increase of rigidity, from the lower to the uper limit. Which term of the above series, that is, which degree of vulcanization is produced, is in every case only a function of temperature, time, and the proportion of sulphur present.

"As a chemical reaction the vulcanization process is not influenced by the physical state of the India rubber colloid; but the physical state of the India rubber colloid while under vulcanization largely determines the physical constants of the vulcanization product."

From the above we conclude that dental vulcanite is essentially polyprene disulphide having the symbol $C_{10}H_{16}S_2$ which contains 32 per cent. of combined sulphur.

ADVANTAGES AND DISADVANTAGES OF VULCANITE AS A BASE FOR ARTIFICIAL DENTURES

Advantages.—1. It is easy of manipulation; it can be molded into any form, and it becomes, upon proper vulcanization, very strong, tough, and flexible. It is repaired with equal ease.

2. It is the lightest of all substances used in the mouth; its specific gravity is from 1.15 to 1.50, while aluminum, the lightest metal suitable for use in the mouth, has a specific gravity of from 2.5 to 2.7.

3. It is inexpensive, both as to cost of material and labor in construction, thus bringing it within the reach of patients unable to afford metal plates.

4. There is no material with which contours can be so easily and perfectly restored.

Disadvantages.—1. It is a very poor conductor. It prevents the proper radiation of heat from the mucous membrane over which it is placed, thereby leading to excessive resorption of the hard tissue and lowering the vitality of the soft tissue, in consequence of which they are more subject to the action of irritants.

2. It is a porous material, and because this condition is greatly exaggerated by improper vulcanization, it affords lodgement for bacteria, the products of which are very strong irritants to the soft tissue.

The physical phenomena of expansion and contraction in the vulcanization process are by some considered as disadvantages, but these can be so well controlled by modern methods of manipulation, that they should not be considered.

Red and pink rubber are by many considered injurious because of the coloring matter, vermilion (mercuric sulphide). This criticism is unjust, because pure mercuric sulphide is insoluble in water, alcohol, alkali, and all acids (except nitrohydrochloric acid), which under no condition should come in contact with red or pink vulcanite, as this

acid converts HgS into $HgCl_2$ (corrosive sublimate). Only high grades of rubber should be used in the mouth, as the cheap grades may contain injurious impurities.

INSTRUMENTS AND APPLIANCES USED IN VULCANITE WORK

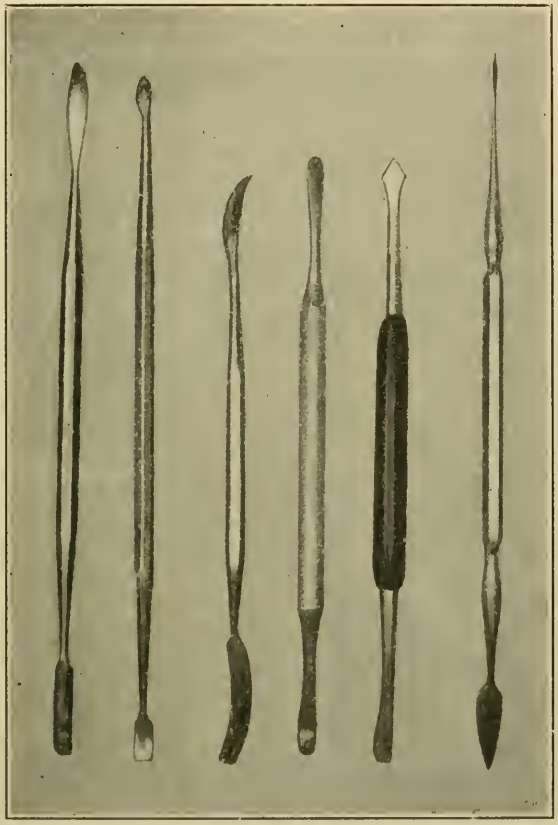
Wax Spatulas.—These are instruments used in manipulating wax. There are different types of these instruments,

FIG. 104

as carvers, ironers, knives, and spoons. Carvers are small knives and scrapers. Nos. 1 and 2 of the Evans set are

of this class (Fig. 104). (The No. 3 of this set is a burnisher for tinfoil.) Ironers have sufficient bulk of metal in their ends to convey heat to the wax. They are of various

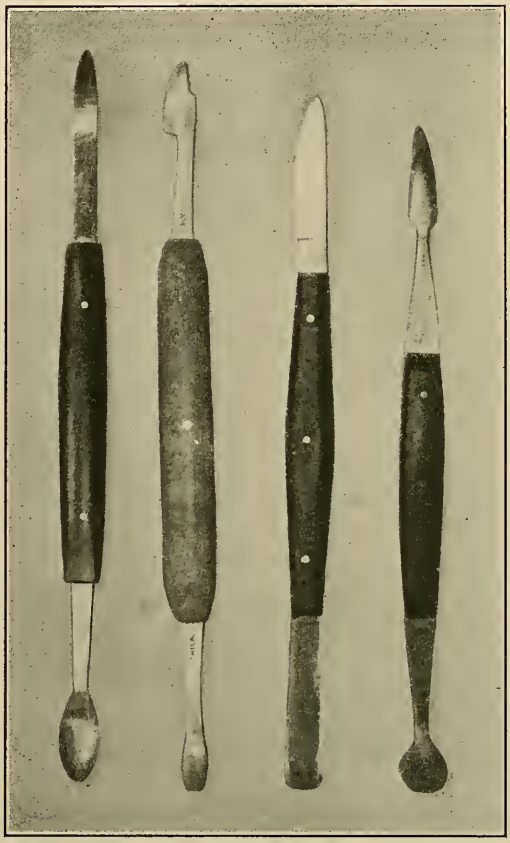
Fig. 105



forms designed to facilitate the work. Fig. 105 shows a number of these instruments. Knives are larger than the knife-shaped carver and are designed for coarser work. Spoons are for melting and carrying wax. These

various classes are often combined in double-end instruments, especially so with the knife and spoon (Fig. 106).

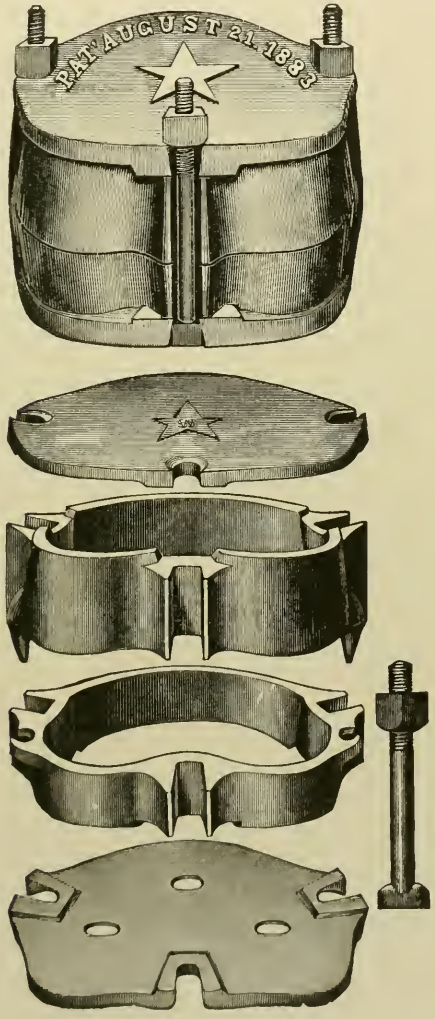
Fig. 106



Flasks.—There are a great many varieties of vulcanite flasks upon the market. They are made of iron or brass. Iron has the greater affinity for oxygen and sulphur in vulcanizing, and so is not as desirable as brass for this purpose. The brass flasks are the more easily cleaned.

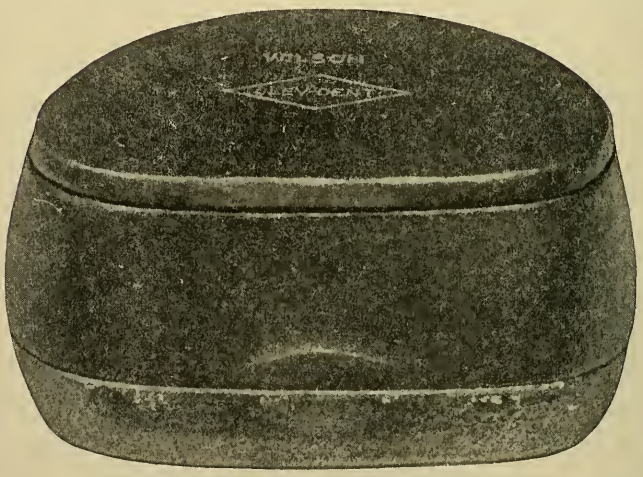
Each time they are used, they should be thoroughly cleaned with a stiff brush and sapolio.

Fig. 107



The Star flask is one of the oldest forms, and, being reversible, is probably adapted to more cases than any other (Fig. 107). The Wilson flask is characterized by a very narrow rim upon the lower section, with a correspondingly wide rim in the upper section. It is designed to be used for full cases only, and with the Donham spring clamp (Fig. 108). The Donham flask is shown in the Donham spring clamp (Fig. 109). The Whitney flask is very much used. There are two sizes, the larger being five-sixteenths

Fig. 108



of an inch deeper than the smaller. Fig. 110 shows the regular size with springs upon the bolts to aid in closing the flask.

The box flask is designed for interdental splints and any extra large pieces of vulcanite. It is made in two sizes, one as large as can be used in a two-flask vulcanizer and the other for the three-flask vulcanizer (Fig. 111).

Flask Presses.—The flask press (Figs. 112, 113, 114) is an indispensable appliance in a well-equipped laboratory, and yet probably its improper use has caused more misfit vul-

Fig. 109

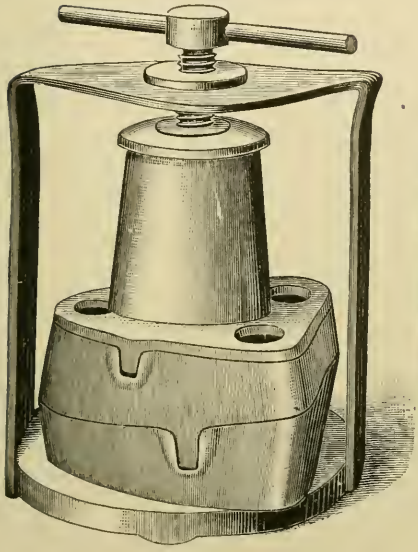


Fig. 110

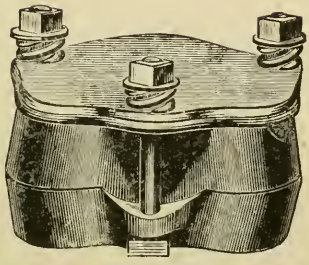
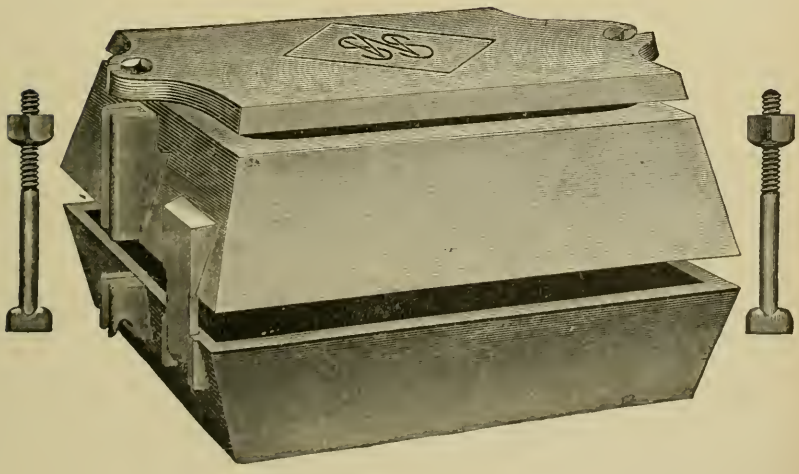


Fig. 111



canite dentures than all other causes. When the principles involved in the flask press and its use are understood, there

Fig. 112

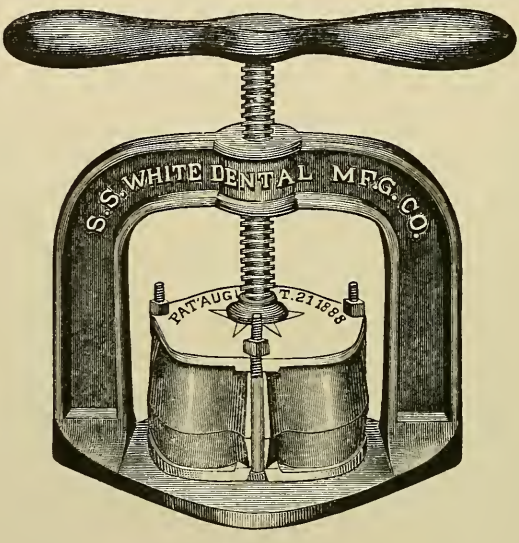
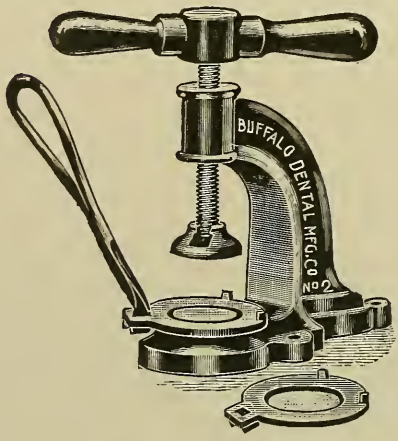
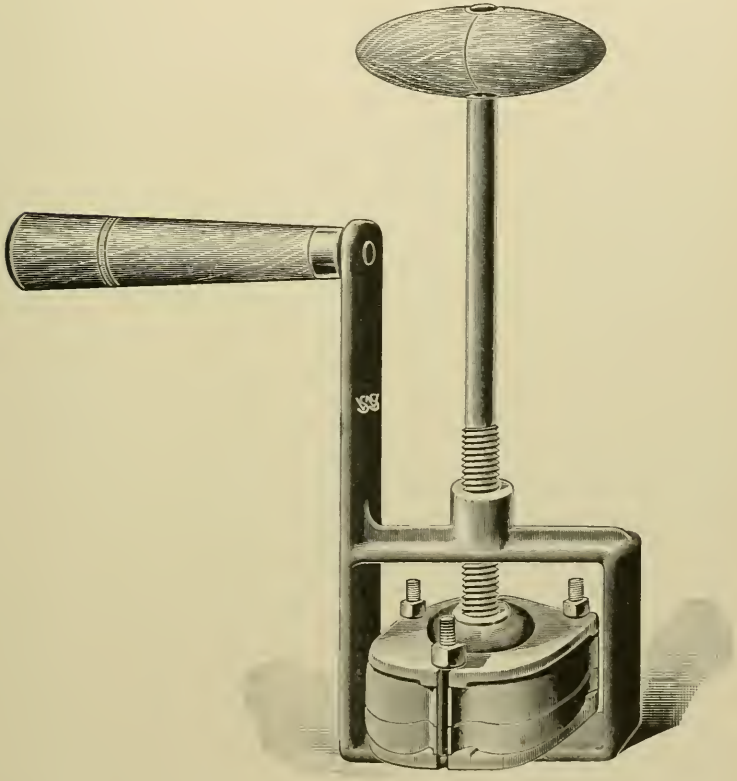


Fig. 113



should be no trouble in handling it. All plasters expand and are compressible, some excessively so. French's regular dental plaster is the best and most commonly used by the profession, so these statements are in connection with this

Fig. 114



plaster. A molar tooth one-half inch in diameter under a thousand pounds' pressure would be driven into well-set plaster one-twentieth of an inch. Rubber when cold is very tenacious and will resist a very heavy pressure for a short

time, but will gradually yield. Plaster compresses to its full extent in a very few seconds. It is easy to comprehend that if an excess of rubber is placed over the teeth upon one side, and heavy pressure is applied, that the teeth will be driven into the plaster encasement and consequently the teeth upon that side of the denture will be too long. It can also be comprehended that if the cast is formed of regular plaster, and excessive rubber and pressure be applied to the vault of the cast, that it will be pressed upward and the plate warped.

We shall now consider the power of the press. The screw is a combination of the lever and wedge, and its power is calculated by multiplying the circumference described by the lever by the pitch of the screw. The Buffalo Dental Manufacturing Co. No. 2 press (Fig. 113) has a handle 8 inches long, hence describes a circumference of 25+ inches. There are ten threads to the inch, hence a pitch of $\frac{1}{10}$ of an inch. An allowance must be made for friction in the screw, but $\frac{1}{5}$ will be very liberal, when we shall have for every pound of force applied at the end of the handle, two hundred pounds' pressure under the screw, or a ton for every ten pounds of force. If the force is applied at the middle of the handle it will produce one-half as much pressure or a ton for every twenty pounds of force. It is now easily understood why plates are warped and these heavy malleable iron presses are sometimes broken.

Vulcanizers.—There are in use at the present time many forms of vulcanizers. It is unnecessary to enumerate them. The description will, therefore, be confined to one of the best examples of the somewhat extensive list.

The Lewis Cross-bar Vulcanizer (Fig. 115) embodies many valuable improvements, and is probably one of the strongest, safest, and most convenient vulcanizers of the cross-bar pattern in use.

The boiler is hand-made from copper, rolled expressly for this form of vulcanizer, and is of unusual thickness. The cap is ribbed on the under side to resist any strain which may be put upon it. This cap has but two holes drilled

in it: one for the mercury bath, to which the thermometer is attached; the other for the "manifold," which carries the safety-valve, blow-off, gas regulator, or steam gauge (Fig. 116). The ring surrounding the boiler is of cast steel, and is therefore of ample strength. Besides the lugs for taking the strain off the cross-bar and bolt, it has a dovetailed projection for the insertion of a lifting handle (Fig. 117).

Fig. 115

It will be observed that when the cross-bar and cap are removed, there are no swinging bolts or attachments to the pot.

The cross-bar is of an improved form, and is made of cast steel. One end is at right angles to the main bar, and terminates in projections which catch under the lugs on the

ring. Over the projections is a small rib which prevents the bar from dropping out of position. The other end of the cross-bar has an enlarged portion for the reception of the bolt, and is terminated by a handle.

Fig. 116

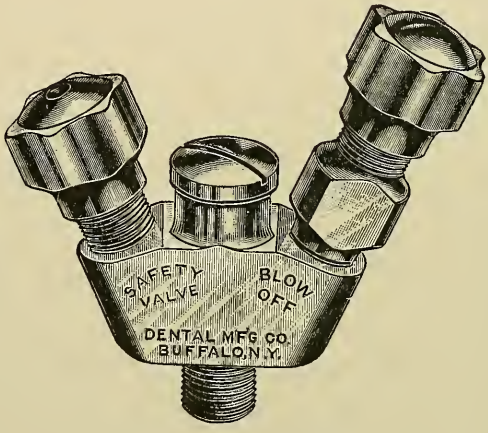


Fig. 117

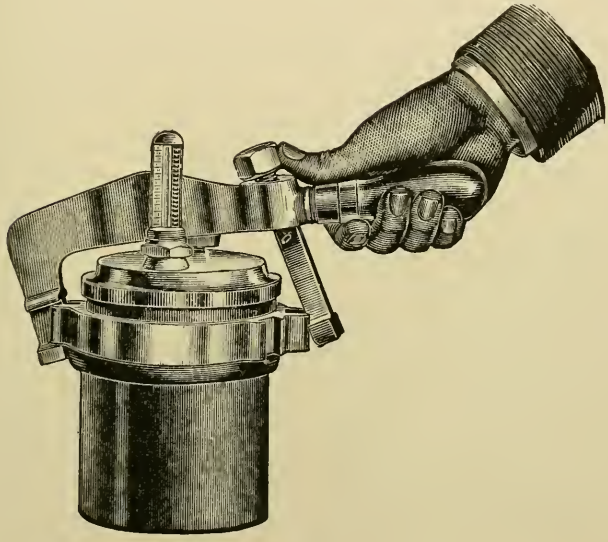
Fig. 118

The vulcanizer is closed by one bolt suspended in a slot on the hand-end of the cross-bar. The bolt is squared to prevent rotation, and is surrounded by a spring for the purpose of disengaging it from the lugs when the nut is loosened, and for always retaining the bolt perpendicularly and forcing it in place automatically.

The vulcanizer is opened by loosening the nut on the bolt by means of the wrench furnished for the purpose (Fig. 118). The bolt will be forced downward through the action of the spring. The handle of the cross-bar is then seized, and with the thumb against the nut it is pressed until the bottom of

the bolt is disengaged from the lugs, when the bar may be lifted (Fig. 119).

Fig. 119

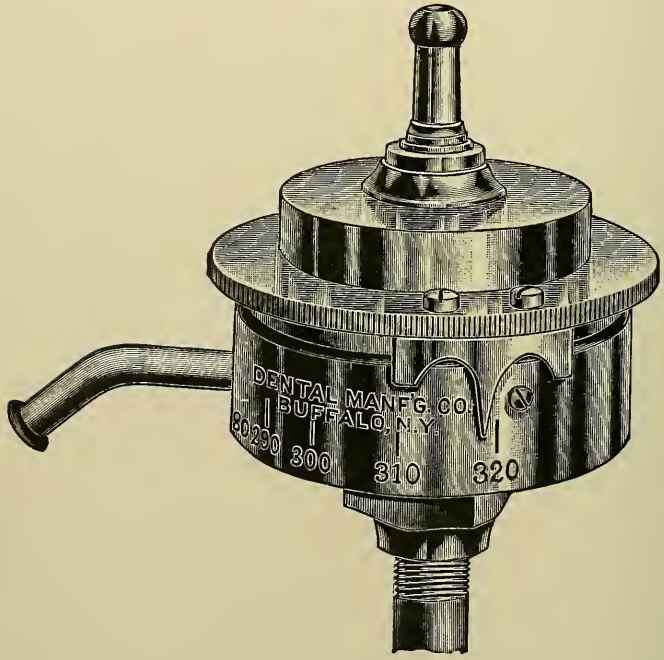


INSTRUCTIONS FOR THE USE OF GAS AND TIME REGULATORS

"The gas regulator (Fig. 120) is secured to the cap by means of the short iron pipe or coil. This is screwed into a hole drilled through the cap of the vulcanizer, and tapped with a 'one-eighth gas-pipe tap.' If the vulcanizer has a 'Lewis manifold' attached to the cap of the vulcanizer, remove the screw between the blow-off and safety valve and screw the coil pipe in its place. After the gas regulator has been properly fitted, place the vulcanizer in the jacket and in the position in which it is to be used. Connections between the time regulator, gas regulator, and gas burner are made by means of rubber tubing. The engraving (Fig.

121) illustrates the correct method of connecting gas and time regulators to vulcanizers. Cut a piece of tubing of sufficient length to reach from the gas-supply tap to the *time regulator,* and connect them; cut off another piece to reach from the time regulator to the *gas regulator,* and attach to the gas regulator by the *upright* or straight nipple

Fig. 120

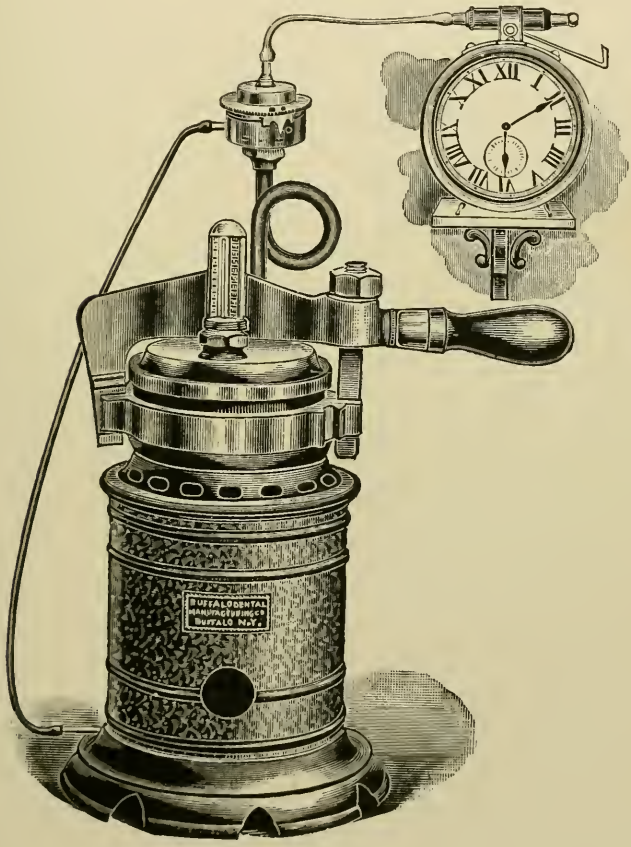


on top of the No. 4 Lewis gas regulator; then connect the downward curved tube of the gas regulator to the gas burner under the vulcanizer with another piece of rubber tubing.

"The time regulator is more convenient when placed on a bracket near the gas-supply pipe. It is then out of the way, and not likely to be broken from contact with tools, and can also be used as a timepiece.

"**To Set the Time Regulator.**—When the valve lever on top of the time regulator (Fig. 121) is engaged with the screw upon the minute arbor on the back of the clock, the valve

FIG. 121



is held open for a length of time depending upon whether the lever is engaged with the first, second, or third thread of the screw; and the lever will be cast off, and the valve

closed when the minute hand reaches the figure XII. When the minute hand is at IX the lever will be cast off at the end of fifteen minutes, if it is engaged with the *first* thread of the screw from the end; an hour and a quarter, if engaged with the *second* thread, and so on. A trial should be made, and the time ascertained which is necessary for heating the vulcanizer to the vulcanizing point, and this time should be added to the proposed time for vulcanizing. We have, therefore, the following:

"RULE.—Turn the minute hand to as many minutes *before the hour* as the number of odd minutes desired; then put the end of the lever in the threads of the screw upon the minute arbor at the back of the clock. The *first* thread from the end gives the odd minutes to which the clock is set; the *next* and *each* succeeding thread gives a full hour. For example: For an hour and twenty minutes, set the minute hand at the figure VIII, and engage the lever in the *second* thread from the end of the screw. At the end of that time the lever will disengage and automatically shut off the gas from the vulcanizer. If this were to be an hour longer—*i. e.*, two hours and twenty minutes—the lever should be placed on the third thread of the screw. For three hours, set the minute hand at XII and engage the lever in the third groove of the screw.

Steam Pressure.—"Those who use vulcanizers should be thoroughly informed as to the nature and properties of steam. The fact should be borne in mind that a vulcanizer is subject to the same laws and conditions as a steam boiler, which it is in fact, and although it is comparatively safe and easily operated, it may, by carelessness or ignorance in its management, become exceedingly dangerous.

"The following table of steam pressure will be found convenient for reference, as it has been corrected so that it shows the true temperature for any pressure indicated by the steam-gauge. Fractions are omitted, and the nearest whole number is used instead. The French table generally used shows 14.7 pounds' pressure at 212°, whereas the steam-gauge at that temperature will indicate 0, unless by

the expansion of heated air confined in the vulcanizer. The gauge is therefore just *one atmosphere* lower than the French table:

TABLE OF THE ELASTIC FORCE OF STEAM[1] (CORRECTED TO CORRESPOND WITH THE STEAM GAUGE)

Degrees of temperature, Fahrenheit.	Elastic force in pounds per square inch.
212	0
220	2
230	6
240	10
250	15
260	21
270	27
280	34
290	43
300	52
310	63
320	75
330	89
340	104
350	120
360	140
370	160
380	180
390	205
400	234
410	264
420	296
430	335
440	375
450	415
460	455
470	515
480	565
490	603
500	663
510	721
520	793
530	864
540	937
550	1015

"It will be noticed that as the temperature rises the pressure of steam increases in constantly increasing ratio

[1] General instructions for operating dental vulcanizers, Buffalo Dental Manufacturing Co., July, 1898.

for equal increments of heat, the pressure being nearly doubled by the addition of 50° to the temperature. This fact will show the *necessity* of care and watchfulness while vulcanizing.

"The bulb of the thermometer is set in a mercury bath. This is the small cup, forming a part of the vulcanizer cap, to which the thermometer case is screwed. This cup should contain sufficient mercury to insure its touching the bulb of the tube when the thermometer case is screwed down properly. This makes a *metallic connection* between the thermometer bulb and the vulcanizer cap, and is *absolutely necessary* for the proper indication of heat by the thermometer.

"Should the mercury column separate, it can usually be reunited by removing the tube from the thermometer case, holding it perpendicularly, and striking the bulb with some force upon the palm of the hand, or by holding the tube by the bulb and giving it a sudden flirt. If the vulcanizer is used with the thermometer in this condition, it should be remembered that it is the *whole column* that denotes the heat, and allowance should be made for the broken part, *i. e.*, if there is enough mercury separated to fill the space of 10°, the remainder of the column should only rise to 10° less than the temperature desired.

"Directions for inserting a new tube in the thermometer case will generally be found on the package containing the tube and scale.

"Thermometers are accurately marked, by test instruments, at the 212° and 320° points, and the scales are especially graduated for each tube, as the positions of the points above named vary in different tubes. *Each tube must, therefore, be used with its own scale,* and in fitting it to the case, care should be taken that the black mark on the tube indicating the 320° point is brought exactly opposite to the 320° point on the scale.

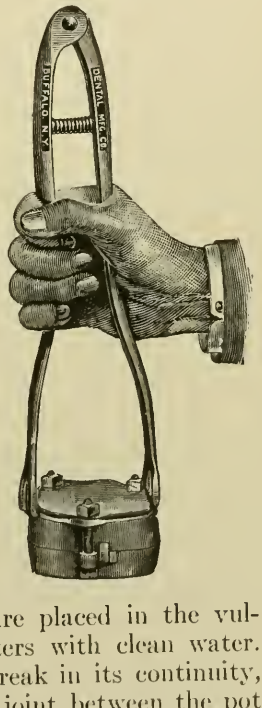
"The thermometer does not always give a correct indication of the heat of the vulcanizer. It only gives the temperature of the vulcanizer top, which may not be that of the flask. In fact, the indications of the thermometers employed

on vulcanizers are almost invariably too low, owing to imperfect conduction of heat, radiation, etc.; and the vulcanization temperature, instead of being 320°, as indicated, is more usually 330° to 340°."

The plan of providing a mercury bath for the reception of the bulb is a great improvement over the old way, and prevents the fracture of the bulb by the great pressure of the steam, which was of such frequent occurrence when the thermometer was in direct contact with the latter.

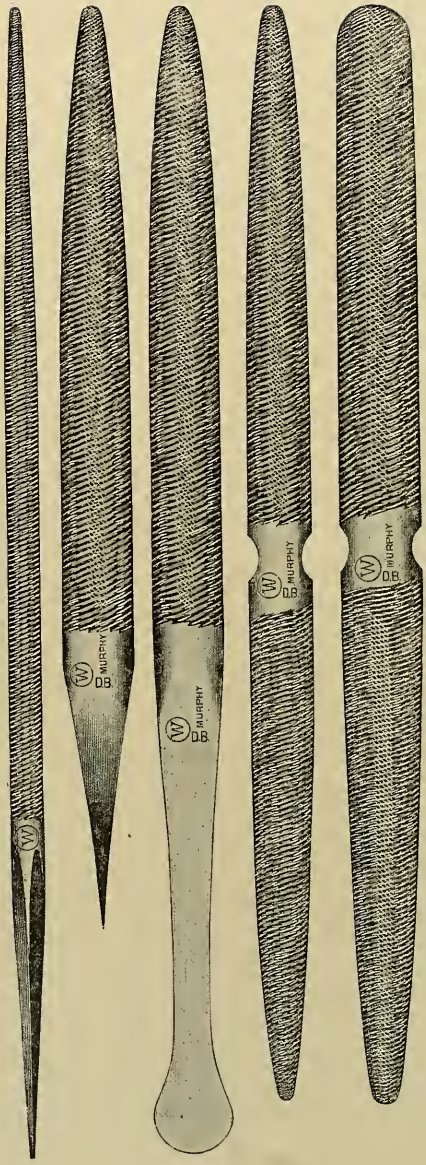
Damage to the glass bulb of the thermometer is manifested by a rise in the mercury, which cannot be brought down to the usual vulcanizing point by turning off the flame of the burner; consequently the thermometer ceases to correctly indicate the degree of heat, and imperfect vulcanization is the result. Leakage of steam around the packing of the vulcanizer should also be guarded against, as in such cases all of the water may escape from the apparatus before the vulcanizing is complete. Loss of all of the water in the vulcanizer may be detected by a persistent fall of the mercury, even when the gas flame is greatly increased, and when this phenomenon is observed, the gas should be turned off, the vulcanizer allowed to cool, and new packing adjusted. Failure to strictly observe this rule has undoubtedly resulted in many serious accidents.

FIG. 122



Vulcanizing.—The flask or flasks are placed in the vulcanizer and filled about three quarters with clean water. The packing should be without a break in its continuity, otherwise the steam will escape; the joint between the pot and cover must be protected from adhesion by slightly coat-

Fig. 123



ing it with black lead or soapstone. The cover is then put on, but the valve is not closed until the heated air which precedes the generation of steam has escaped; the valve is then closed. A close watch must be kept on the thermometer or gauge until the vulcanizing point is reached, unless a time regulator is used.

FIG. 124

Flask-tongs.—Fig. 122 shows a useful form of flask-tongs for lifting flasks from the vulcanizer. They are made of sufficient length to reach the bottom of a three-case vulcanizer, and will securely grip the flask.

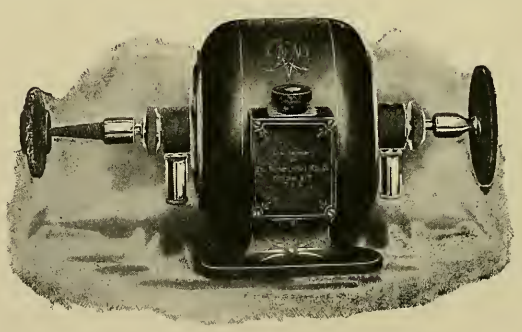
Files.—Fig. 123 illustrates some excellent forms.

Vulcanite Trimmers.—There are a great variety of scrapers and chisels from which each operator may select such as seem best adapted to his hand. The writer's preferences are the ones here illustrated (Fig. 124).

GRINDING AND POLISHING

In the construction of artificial dentures upon any base, grinding and polishing are very important operations and require efficient equipment for their accomplishment. For this purpose a small lathe of suitable construction is necessary. These lathes will require approximately one-sixth horse-power, which may be provided by either electricity, water, steam, or the foot. The desirability of the power

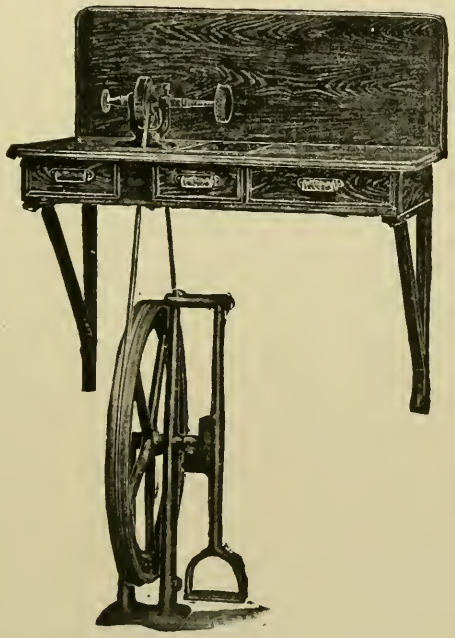
Fig. 125



chosen is in the order named. However, steam is rarely used in a dental office because of the expense of installing and maintenance. There are many patterns of these implements from which the dentist may select. There are two general principles involved in all of these appliances: (1) The motor and lathe are combined as one implement; (2) the motor and lathe are separate and coupled together with a band or cord.

The electric current is most convenient and serviceable when it can be had in the office. Fig. 125 represents an apparatus of the first type, that is, motor and lathe combined. This electric lathe is admirably adapted to general laboratory uses or as an operating room lathe. Its bearings are completely protected from dust. It is noiseless, and is

FIG. 126



constructed with such precision that its motion is hardly perceptible. It is adapted to the 110-volt direct current, and has sufficient power for all purposes required by the dentist. It requires no special table, hence can be placed in any position at the convenience of the operator. It has a range of speed varying from 1000 to 4000 revolutions per minute. The regulation of the speed, and starting and

stopping of the lathe are effected by the milled stud. The chucks are held upon the shaft of the motor by friction, and can be removed while the motor is in motion or stationary by turning the milled nuts near the ends of the shaft. These motors can be obtained for other voltages and for the alternating current.

Fig. 126 is a lathe of the second type, and can be operated by any power through a cord. This illustration shows a convenient arrangement of lathe and foot power.

These lathes are all provided with various forms of chucks for grinding stones, buffers, and polishing brushes. Figs. 125 and 126 each show a stone mounted chuck upon one end of the shaft, and the tapered screw cut spindle for buffers and polishing brushes at the other end.

Fig. 127

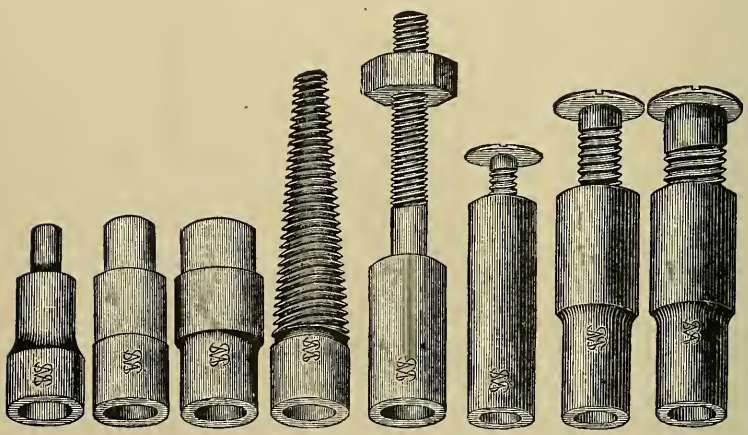


Fig. 127 is a typical set of chucks, and Fig. 128 a lathe head. Most makers of lathes furnish an extra clutch chuck for burring engine instruments. Fig. 129 shows such a chuck. Fig. 130 shows an additional nut the author has had added to the clutch chuck for his lathe. By this means a three by one-half

inch carborundum stone is mounted. The figure also shows an engine mandrel mounted with a small stone in the clutch. The author has no use for any other stone chuck, and no changes are required except in the small stones, burs, and

FIG. 128

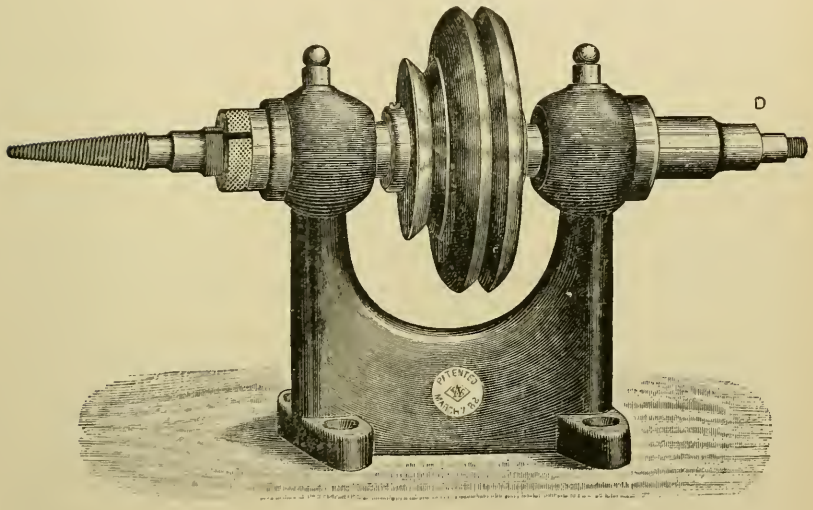
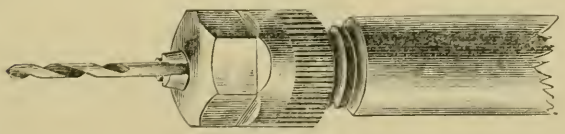


FIG. 129



bits used in the chuck. Fig. 131 is the "Ideal Emery Cloth Arbor," put upon the market by Samuel A. Crocker & Co., Cincinnati. This is an especially useful addition to the lathe for vulcanite work.

The lathe should be kept clean, well oiled, and true running. Grinding is a very important accomplishment—indeed, it

may be called a fine art in mechanical dentistry—and can be acquired only by technical training and the use of true-

Fig. 130

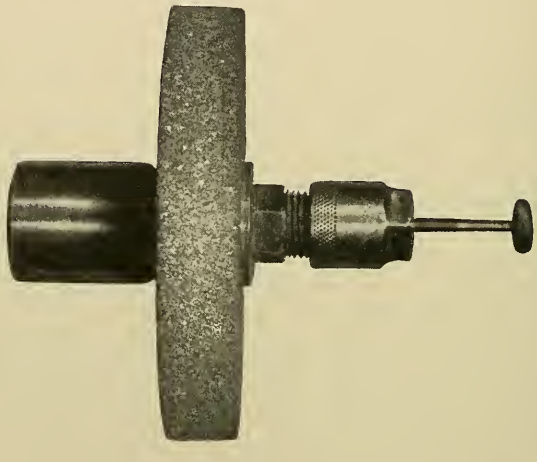


Fig. 131

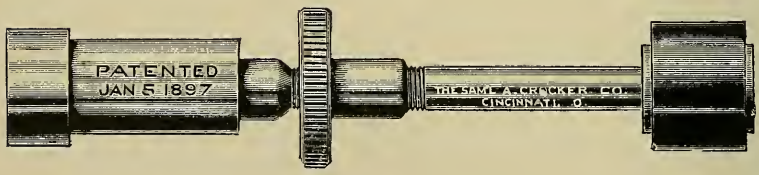
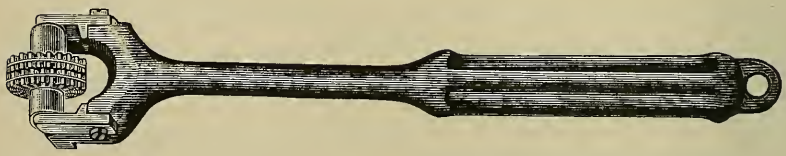


Fig. 132



running and well-cared-for equipment. Next to the lathe running true, the stone must be kept true and sharp; this is

accomplished by the use of a machinist's emery stone dresser (Fig. 132). This stool is used over a firm support, with a moderate pressure, upon the rapidly revolving stone. It not only produces a true surface, but a very sharp cutting one. The tool should be applied often.

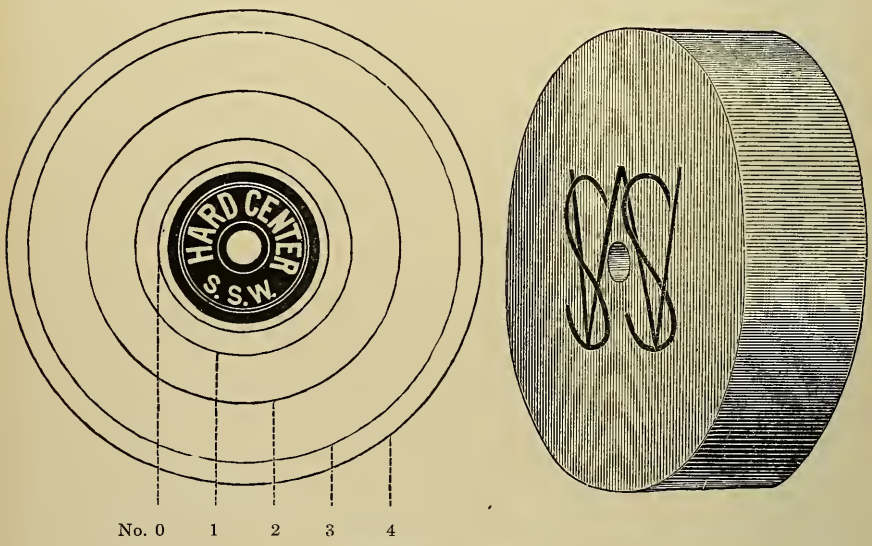
Stones.—The stones used in the dental laboratory are made of either corundum or carborundum.

Corundum is a mineral found in Ceylon, and in Pennsylvania, Georgia, Massachusetts, and North Carolina. It occurs in crystals of the form of double six-sided pyramids of various sizes, and in some localities in large masses without crystalline form. Corundum is an aluminum oxide having a formula Al_2O_3. Emery, the use of which preceded corundum as an abrasive agent in the dental laboratory, is a coarse variety of corundum. Corundum is prepared for use by crushing in an iron mortar. The required size grit is mixed with finely ground shellac in the proportion of 3 ounces of corundum to 1 of shellac, and formed in iron molds by the aid of heat and pressure. The surface shellac is dissolved out with alcohol, leaving the abrasive crystals exposed. Wheels made of corundum require to be run wet, otherwise the frictional heat will draw the softened shellac bond to the surface, producing a glaze which is non-abrading.

Carborundum is a manufactured grit; it is harder and more brittle than corundum, and is next to the diamond as an abradent. Carborundum was made experimentally in 1893 by Mr. G. E. Acheson, and is now manufactured on an extensive scale at Niagara Falls. It is made of a mixture of finely divided coke, pure silica sand, sawdust, and salt (NaCl). Ten tons of this mixture is placed in a furnace 16 feet long by 6 feet wide and 8 feet high. Electrodes are connected at the centre of each end with a core of crushed coke. About 1000 horse-power of energy is utilized at an average voltage of 185, reaching a temperature approximating 7500° F. The salt acts as a flux. The sawdust burns out, leaving the mass porous for the escape of gases. The current is applied for thirty-six hours; it is then withdrawn and the mass given time to cool. About two tons

of crystals are formed about the core, consisting of the carbide of silicon (CSi). These crystals are crushed, washed, and sieved, mixed with feldspar and clay as a bond, molded into shape under heavy pressure, and burned in a kiln for several days. Wheels made of carborundum may be run either wet or dry. It is claimed for them that they do not clog; however, the surface becomes so filled with dust that they are not nearly so effective as when tooled as previously described. The wheels have a tendency to wear untrue, probably due to imperfections in the mixing with the bond and burning in the kiln. Frequent tooling overcomes this defect and keeps them true and sharp until they are worn out.

FIG. 133



Represents No. 4 wheel.

Buffers.—Buffing wheels and cones are used on the thread-cut spindle in finishing the denture; they carry fine abradents and remove small defects and scratches from the surface of the work. They are made of various materials, as

Fig. 134

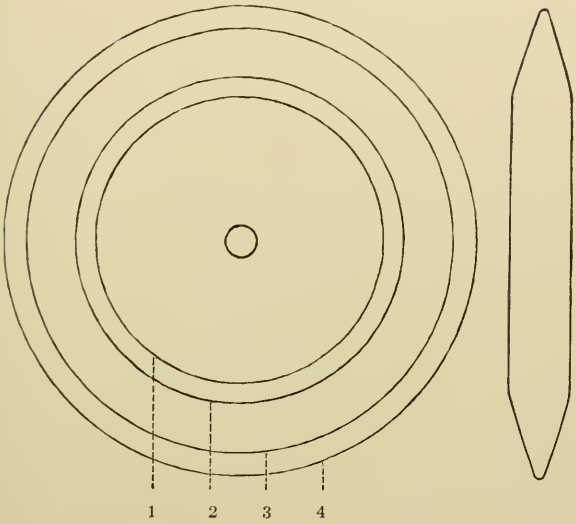
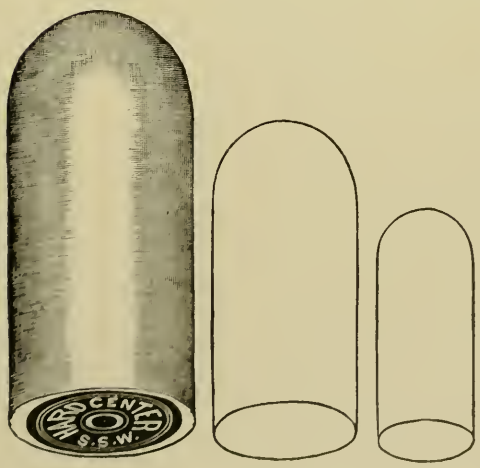
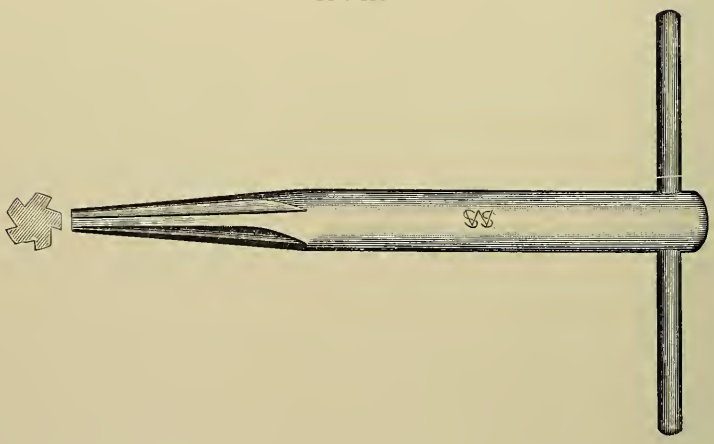


Fig. 135



felt, cotton, duck, leather, soft wood, cork, and disks of cloth or chamois leather stitched together. Felt is probably the best and most commonly used material for dental buffers. The wheels are made in various sizes and shapes. A wheel two or two and one-half inches in diameter and one-half inch thick is an excellent size. Knife-edge wheels are very useful in some places, but they must be properly used or they will quickly cut a groove. They also wear away rapidly, thus destroying the knife-edge effect. They require frequent tooling with a knife or chisel to keep them turned to an edge. Figs. 133, 134, and 135 show a square-edge wheel, knife-edge wheel, and cone respectively.

Fig. 136



Brushes.—Brush wheels, both stiff and soft, are used. These wheels are made in various forms. Their wooden centres, which are straight drilled, should be reamed to a taper. Fig. 136 shows a suitable reamer. They are used on the threaded taper spindle. The bristles are either straight, converging, or diverging. The stiff converging wheel is excellent for carrying the abradent between the teeth where the felt cannot reach. The soft bristle brush

Fig. 137

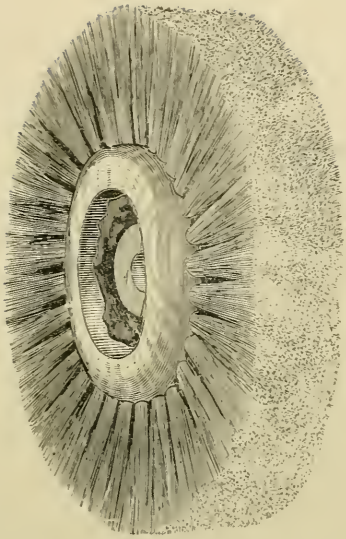
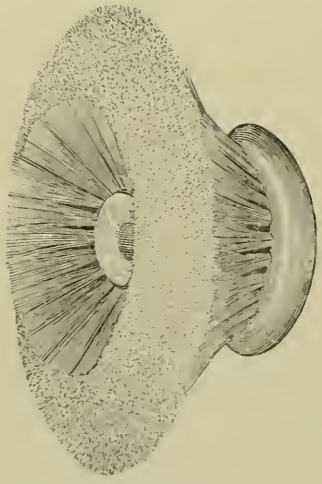


Fig 138

Fig. 139



is used to carry the finest abradent and produces the gloss. Figs. 137, 138, and 139 show three forms of brushes for the lathe.

Finishing Powders for Vulcanite.—Pulverized pumice stone for buffing and prepared chalk for glossing are especially suited to vulcanite work.

Pumice stone is volcanic scoria or lava. Chalk is calcium carbonate, a soft variety of limestone; it is prepared by freeing it from particles of coarser grit.

Use of Stones.—The stones are used to grind the porcelain teeth, sharpen instruments, etc. It is safer to run the stone at a slow speed. There is danger of chipping and checking the porcelain by the pounding of an untrue stone and heat produced by a clogged one. If the stone is true and clean, and the tooth held with light pressure, it will be rapidly cut with hardly perceptible frictional heat, consequently no chipping or crazing of the porcelain. By the same care a steel instrument may be ground without drawing its temper, as indicated by the blue color and spoiled cutting edge. A higher speed may be used, but greater care is required.

Buffing.—The buffing is done by first using the large felt wheel and pulverized pumice stone. The work, the felt, and the pumice must be kept thoroughly wet, otherwise sufficient frictional heat may be generated to roughen the vulcanite and possibly warp the denture. It should be obvious to the student that if the work is held at one place against the felt carrying an abradent a depression will be cut into its surface. Hence the work while being held against the buffer must be kept in constant motion. This motion should be a steady systematic procedure, not of a jerky, indecisive type. The denture should be finished with true symmetrical convex or concave surfaces in keeping with the conformation of the part. Facets show either inexperienced or careless buffing. The buffer may be run at high speed, in which case the work must be held with moderate pressure only against the buffer. Usually it is safer to use a moderate speed and greater pressure, and in

some places it is wise to use the lowest speed and light pressure. The buffer does not cut of itself, but it carries and applies the abradent, therefore the efficiency of the buffer is largely due to the manner in which the abradent is applied. The abradent, saturated with water to the consistency of soft mud, is applied to the surface to be buffed; and the farther edge is placed against the well-moistened buffer. The buffer engages a small amount of the abradent and carries it over the surface of the work. As the buffer wheel rises from the surface of the work, it throws off a portion of the abradent, but a small portion is embedded in the surface of the buffer to be again carried over the surface of the work. As the work is pushed forward, more abradent is engaged and made to serve its purpose. The work is given a sideways movement as well as a forward one until all of the abradent is removed from the surface of the work. More abradent is applied and the operation repeated until the work is suitably finished. If the buffer is applied to the nearer edge of the abradent and the work drawn forward the buffer will push away the abradent, of which only that portion adhering to the buffer and making the complete circuit will be effective. This method is wasteful of abradent, time, and energy.

Glossing.—The glossing is done with the rapidly revolving soft brush wheel and the prepared chalk. The chalk well moistened with water or alcohol is applied to the surface of the work and held lightly against the brush wheel. As in buffing, the work is pushed against the brush. With the beginning of glossing the brush wheel is moistened, but later is run dry. Alcohol is the preferred moistener for the glossing powder because it serves to attach the powder to the work and quickly evaporates, leaving the powder in a dry condition, best for glossing.

HEAT

In vulcanite work heat is required for warming wax, rubber, flasks, and converting the rubber into vulcanite.

Bunsen Burner.—For all these operations the blue or Bunsen flame only is suitable. Fig. 140 shows a Bunsen burner designed for the laboratory bench and connected to the gas cock with rubber tubing. Fig. 141 shows a

Fig. 140

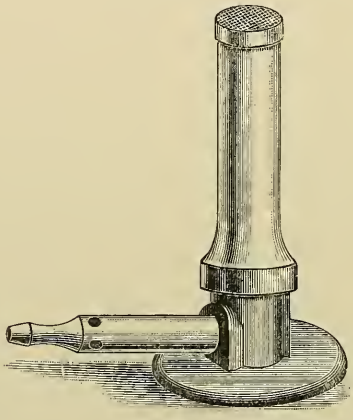
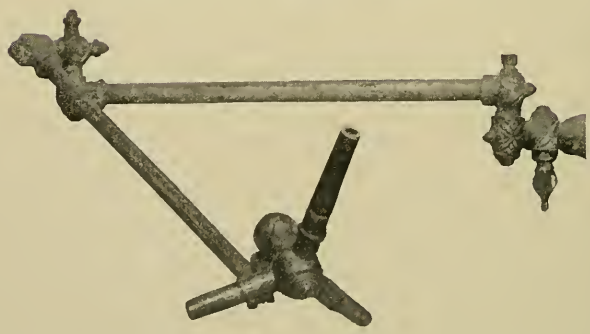


Fig. 141

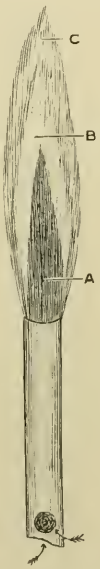


jeweller's triple burner, one of which is a Bunsen. This burner is especially useful because it can be attached to a jointed bracket, thus doing away with the gas saturated rubber tubing. One of the other burners gives a light

flame, and the third burner gives a flame suitable for soldering. These extra burners are often convenient. The burner in the upright position only is in commission, and when any one of the burners is turned straight downward the gas is cut off from all of them.

Construction.—It consists of a straight tube with a suitable size hole near the lower end for the admission of air in sufficient quantity to produce instant combustion of the carbon, thus giving a blue smokeless flame.

Fig. 142



Nature of the Bunsen Flame.—Fig. 142 is an illustration of the Bunsen tube and flame. A flame is gaseous matter heated to a state of incandescence. The flame has a three-cone structure: *A* shows the mixed gas and air being heated; the inner edge of the light cone *B* indicates that the gaseous mixture has reached the state of incandescence and has become a flame; the outer edge of the light cone *B* indicates where the greatest heat has been attained and that the flame from this point outward is cooling until the outer edge of cone *C* is reached. At this point the mixed gases have become chemical compounds and cooled below the temperature of incandescence, hence the flame ceases to exist. It is evident that the greatest body of heat is between *B* and *C*, consequently this is the portion of the flame in which to quickly heat an instrument.

Fig. 143 is a gas stove of many Bunsen jets, and is suitable when a much greater amount of heat is required than can be produced with the small burner.

Alcohol and Gasoline.—In some of the large office buildings in cities, and in many of the small towns, gas is not obtainable as a source of heat; then recourse must be had to either alcohol or gasoline. Alcohol is suitable as a substitute for the Bunsen burner for working wax and resinous compounds;

it is cleanly, odor not offensive, but the heat is slow. Fig. 144 shows a good form of waxing lamp. Gasoline is more powerful and less expensive, but the odor of the material and

Fig. 143

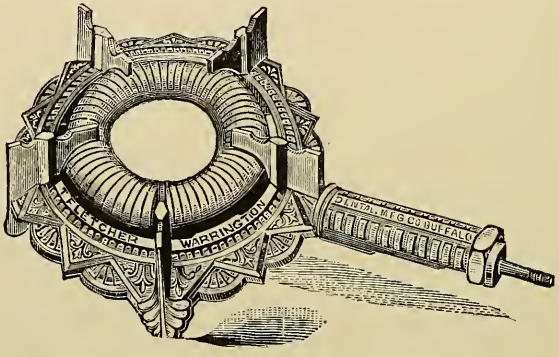
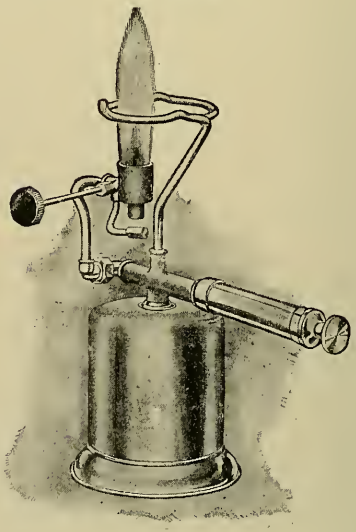


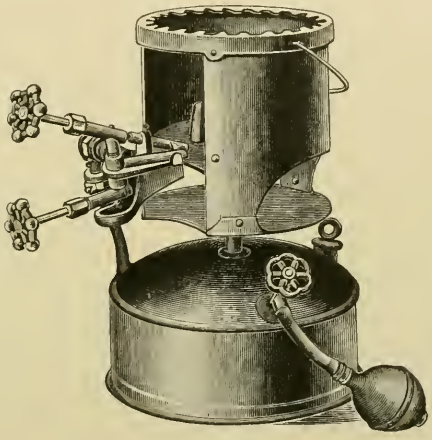
Fig. 144

Fig. 145



of the product of its combustion are disagreeable. Fig. 143 is an excellent Bunsen burner. Fig. 146 is a large heater suitable for general heating purposes in the laboratory.

Fig. 146



Petroleum.—Oil seems to be better adapted for the vulcanizer than either alcohol or gasoline. The lamp for using oil needs no description, for a suitable oil burner may be had for every make of vulcanizer.

TECHNIQUE OF CONSTRUCTION FOR COMPLETE VULCANITE DENTURES

Synopsis.—Diagnosis and prognosis; impressions; casts; base-plates; occlusion and contour models; mounting on the New Century Antagonizor; grinding and setting up the teeth; trying in; flasking; packing; vulcanizing; and finishing.

Diagnosis and Prognosis.—The imaginary patient for whom complete artificial dentures are to be constructed is a lady, aged forty to fifty years, of the blonde type, but not stout built (sanguine temperament, nervous temperament modi-

fication), and good health. The mouth has been edentulous for at least two years; the gums are well resorbed and oval in form; the vault is medium in height and oval in form. There is a moderate amount of submucous tissue underlying the mucous membrane; no pronounced hard or soft places, and the fluids of the mouth abundant but not ropy. A normal average case. The prognosis is favorable, provided the personal equation does not present unusual difficulties.

Impressions.—For the upper impression, see Chapter II; classification, normal. Points to give attention: Tray with flanges low enough not to be displaced by any muscular action; palatal border wax accurately adjusted; cuspid eminence wax; plaster with hastener mixed thin; heel of tray adjusted first; lip raised while adjusting the anterior portion of tray; tray supported with the index finger in the centre of the vault; lip and cheeks drawn downward marking the frenæ, and external compression.

For lower impression, see Chapter II; classification high ridge, broad. Points to give attention: Flanges; lingual wax roll; plaster with hastener mixed thin; the buccal tissues drawn from under the buccal flanges; frenæ marked; external compression, and the tray held in place by pressure of the thumbs in the bicuspid region.

Casts.—The impressions are permitted to stand for a few minutes, then varnished with thin shellac, and when dry (three to five minutes) with thin sandarac. As many coats of sandarac should be applied as may be necessary to secure a glossy surface, permitting each coat to dry before applying the next one. The impressions are filled with Spence compound of the consistency of stiff putty, or a slow, hard setting plaster may be used; either must be thoroughly jarred into place. (See Chapter III.)

Base-plates.—Heavy tinfoil (No. 20 to 60) is placed upon the cast, over which a sheet of paraffin base-plate wax is adjusted (any of the resinous base-plate stock material may be substituted for the paraffin). Soft wax is built upon the base-plates to form the occlusion and contour models as described in Chapter IV.

Occlusion and Contour Models.—The models formed on the casts are tried in the mouth, removed and added to or cut away as may be necessary to give the proper restoration of the lower third of the face at rest. The models should be tested with a spatula, to see that they rest with uniform pressure upon all portions of the alveolar processes. The patient is exercised in the forward and backward movements of the mandible. These movements being made at command, the mandible is placed in the retruded position and the occlusion guide lines, the high and low lip lines, and the median line recorded in the wax. The lower model is removed from the mouth and the bite gauges adjusted. The model is then replaced and the mouth closed in the protruded position, recording the inclination of the condyle path. The bite gauges are removed from the lower models and the fork of the face bow attached to the upper model. The face bow is adjusted and the relationship of the wax model to the condyle secured. (See Chapter IV.)

The student could justly conclude that all of the preceding work is done at one appointment with the patient. However, it is not necessary to detain the patient after the impressions are secured; a second appointment may be made for the next step. During the absence of the patient the impressions are glossed, filled, and permitted to harden for an hour or two. The impression is then removed from the cast (see Chapter III), the base-plate formed, and the preliminary work done upon the wax model. At the second appointment the wax models are adjusted to the mouth and the required data of marks and measures secured. The color of the teeth is selected. The detail of determining the color cannot be discussed; suffice to say that this phase of the science will be discussed in the chapters on Porcelain Teeth and Esthetics; also that the color for the type of the imaginary patient must be straw yellow modified with gray, probably shade 39 or 41 of the S. S. W. shade bar; possibly as much toning with gray will be required as represented in shade 40. The patient is again dismissed with an appointment for another sitting. During the absence of the patient the casts

and wax models are mounted upon an antagonizor, the teeth selected, ground, and set up. At the third appointment the teeth mounted on wax are tried in the mouth. The details of this sitting are discussed in the chapter on Esthetics. At the fourth appointment the finished dentures are placed in the mouth and thoroughly inspected before dismissing the patient.

Mounting on Antagonizor.—The face bow with the wax models and casts are assembled and mounted on the New Century antagonizor, as described in Chapter V. The face bow removed, the bite gauges are used to secure the inclination of the condyle path, as described in Chapter V.

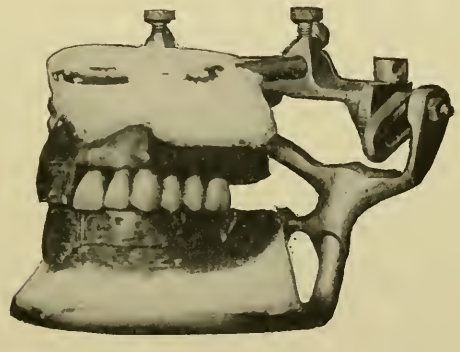
Grinding and Setting Up.—A section of the wax of the upper model, represented by the median and high lip lines, is removed with a warmed wax knife (Fig. 106). The esthetics involved in selecting the artificial teeth cannot now be discussed; however, a rule may be given for determining the size of the teeth. *Length:* The length of the teeth selected should be sufficient to fill the space between the high lip line and the occlusal plane. *Width:* The crest of the cuspid teeth beginning with its cusp should be continuous with the crest of the cuspid eminence developed in the contoured wax model (see Chapter I, also Fig. 2); therefore, the combined width of the central, lateral, and the mesial plane of the cuspid is the length of the space from the median line to the crest of the cuspid eminence. The distal plane of the cuspid and the bicuspids and molars should fill the space between the crest of the cuspid eminence and the maxillary tuberosity. This rule for length and width is only applicable to normal or nearly normal cases. Extreme and abnormal cases cannot be classified, and artificial teeth must be selected according to the judgment of the prosthetist.

Grinding.—There are two stages of grinding a set of artificial teeth. The first stage is grinding for occlusion at the time of setting up the teeth. The object is to gain as large a contact surface as may be expedient, and to so face the surfaces as to crush the food without dislodging the dentures. The second stage is at the time of final

finishing of the dentures, and is designed to produce edges for catching and cutting the food; also to remove such points as may interfere with antagonization. The first stage of grinding may be done before any of the teeth are set up, or each tooth may be ground just before setting up. The first method is more expeditious for an experienced workman, but the second method is more comprehensible for the student and is the one here described.

Setting Up.—As the patient is in middle life, the anterior teeth must be ground to represent slight wear. This is done by slightly grinding the incisal edge of the incisors so as to give a moderately sharp straight edge, removing the rounded

FIG. 147

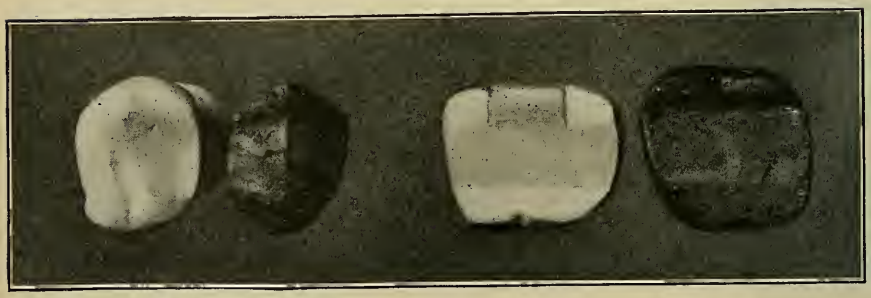


edge of youth. The central incisor is set in place and secured with melted wax (Fig. 147). Setting up the teeth may be facilitated by placing a small roll of softened yellow wax upon the wax model into which the cervical end of the teeth are pressed and thus held while the lingual portion is being filled with melted wax. This lingual wax may be added by dropping on from a pencil or stick of wax, the end of which is melted in the Bunsen flame, or, the melted wax may be carried to place in a wax spoon (Fig. 106). The lateral incisor, with its incisal edge straightened, is set next to the central. The cuspid with its mesial incisal edge ground, thus placing the apex of the cusp more distally, is secured

in place. These three teeth fill the space from the high lip line to the occlusal plane, and from the median line to and including the cuspid eminence. Their labial surfaces describe the segment of an arc, the radius of which is the straight line from the mesioincisal angle of the central incisor to the distoincisal angle of the cuspid. The buccal surface of the bicuspids and molars form a straight line, but one which diverges from the median plane of the mouth. The bicuspids and molars are all ground so as to present three surfaces to its antagonist. This is best understood by studying Figs. 148 and 149. The bicuspids must have the three planes upon both the mesial and distal occlusal surfaces, while the molars have but the three straight planes. The first and second bicuspids and first molar (see Fig. 147) are set in order with their buccal surface forming the straight diverging line. If the segment of the circle described by the three anterior teeth is continued, it will pass through the buccal cusp of the

Fig. 148

Fig. 149



first bicuspid and diagonally through the sulcus of the second bicuspid (Fig. 9). The second upper molar is not set until the lower teeth are mounted. The wax about the six mounted teeth (Fig. 147) is smoothed and cooled so as to securely hold them.

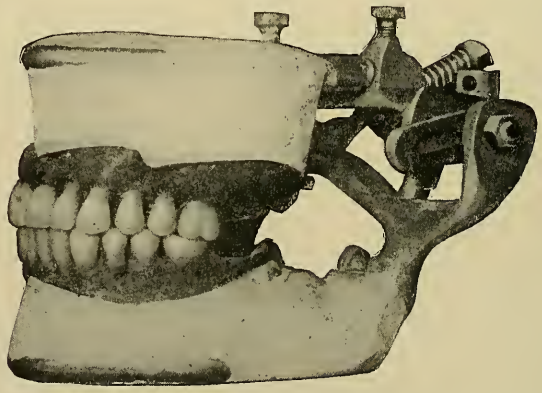
The segment of wax between the median and high lip lines upon the other side of the wax model is removed with a warmed wax knife. The six teeth for that side are then ground, set up, and waxed securely.

The method for grinding and setting up the lower teeth is similar to the upper; however, there are some important modifications. The section of wax defined by the median and low lip line upon either side is removed and a small roll of wax added into which the cervical end of the teeth are inserted. The grinding of the lower teeth differs from that of the upper in this: The facet formed on the incisal edge of the upper looks lingually, while that formed upon the lower incisors looks labially. The mesial edge of the upper cuspid is extended, while in the lower cuspid the mesial edge is shortened. The mesiodistal groove formed in the upper bicuspids and molars is on the buccal side of the centre of the tooth, while it is placed lingually on the lower (Fig. 149).

There are two methods for setting up the lower teeth. One method begins by setting first the second bicuspid so that it shall accurately intercuspate with the upper first and second bicuspids. This is followed in order by the first bicuspid, cuspid, lateral, central, and then the first molar. The other method begins with the central incisor and continues in order backward. The reason for beginning with the anterior is to assure the desired expression, and that the lower teeth shall be clear of the upper ones by nearly one-sixteenth of an inch. The upper anterior teeth should overlap the lower, but for mechanical reasons they cannot overlap one-third the length of the crown, as in typical natural teeth. The amount of the overbite will be governed by the angle of the condyle path and will be adjusted at a later stage of the operation. The difficulty encountered by this method is to get the bicuspids to interlock. This often requires that the anterior teeth overlap each other laterally, especially the cuspid overlapping the lateral. To properly overlap any of the anterior teeth, either lower or upper, the mesiolingual angle of the overlapping tooth should be ground away for nearly its entire length. Also to interlock the bicuspids

it may be necessary to soften the wax about the upper bicuspids and molar and move them backward. *However it may be accomplished, the bicuspids must interlock or intercuspate.* These six lower teeth being secured with wax, the segment of wax on the other side of the median line is removed and the six teeth mounted on that side. Fig. 150 shows the twelve upper and the twelve lower teeth mounted to a straight horizontal plane. Should any of the teeth be loose in their setting, they are made fast by remelting the wax about them with an ironing spatula (Fig. 105), and the wax about all of the teeth thoroughly chilled for the next step of setting the lower second molar.

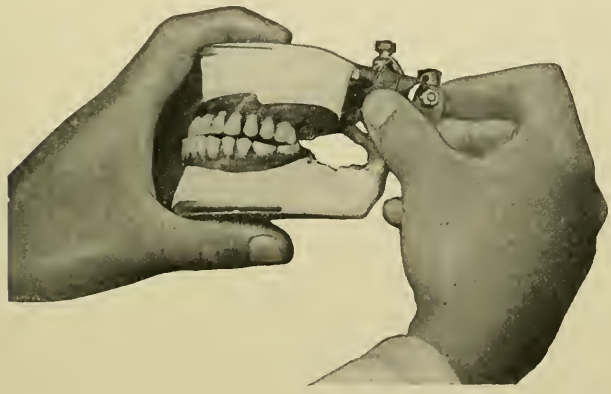
FIG. 150



A portion of the hardened wax just back of the lower first molar is removed and a ball of softened wax set in its place. The occlusal surface of the second molar is ground into the same form as that of the first molar, and set upon the softened ball of wax. The plane of the occlusal surface of the second molar should be nearly parallel with the plane of the condyle path, and the tooth should be so placed that the disto-occlusal margin of the upper first molar will glide upon the buccosulcus plane of the lower second molar when the teeth are placed in lateral occlusion. Fig. 151 shows the teeth

in lateral occlusion and the distoocclusal margin of the upper first molar in contact with the lower second molar. It is obvious that if all the teeth but the lower second molar are set in hardened wax, and it in softened wax, working the condyle joint forward and backward repeatedly will aid in properly adjusting the second molar. Correctly placing the three molars, the upper first and the lower first and second, is the key to the mechanico-anatomical antagonization; and the secret for success in the adjustment of these molars is in keeping the disto-occlusal margins of the first molars *down*. They may be depressed a trifle below the

FIG. 151



plane, but never elevated above the plane. Herein is the distinction between the mechanico-anatomical arrangement of artificial teeth and the variously advocated "anatomical" arrangement of them. By observing Figs. 1, 2, 3, and 4, it will be seen that the anatomical arrangement of natural upper teeth is that the occlusal surfaces of all the teeth, from the central incisors to and including the distobuccal cusp of the first molars, are in a straight horizontal plane, and that the second and third molars are not tilted, but stepped upward. So far as the author knows, no advocate of the so-called "anatomical articulation" has ever suggested repro-

ducing this upward stepping of the second and third molars. Hence there never has been a system of anatomical arrangement for artificial teeth, for they have all been adaptations, and all to a greater or less extent have opposed a physical law. The physical law is that "force moves at right angles to the surface from which it emanates." Therefore, it is evident that the system that least opposes this physical law is superior in at least this one respect. It is evident that if the molars are tilted upward at any angle (the greater the angle the greater the leverage), the closing movement of the mandible must force the upper denture forward, and that if it were not for the interlocking of the bicuspids the denture could not be retained in its place. As the first molars must assume the burden of crushing hard food, it is logical to reason that their occlusal surfaces should be parallel to their alveolar base of support. If the crushing of food were the only function of artificial dentures, then the second molars should be placed in the straight occlusal plane; however, it is important to grind the food, and to have the dentures so constructed that they are balanced in any position in which they may be occluded. To obtain this balanced relationship of artificial dentures it is necessary to have more or less of the teeth placed in harmony with the condyle path; but to secure the greatest effectiveness in crushing and grinding the food, it is necessary to have as few teeth out of the horizontal occlusal plane as possible, hence the short balancing curve, or "compensating curve." This term "short balancing or compensating curve" is in contradistinction to the *long* "compensating curve," as first taught by Dr. Bonwill.

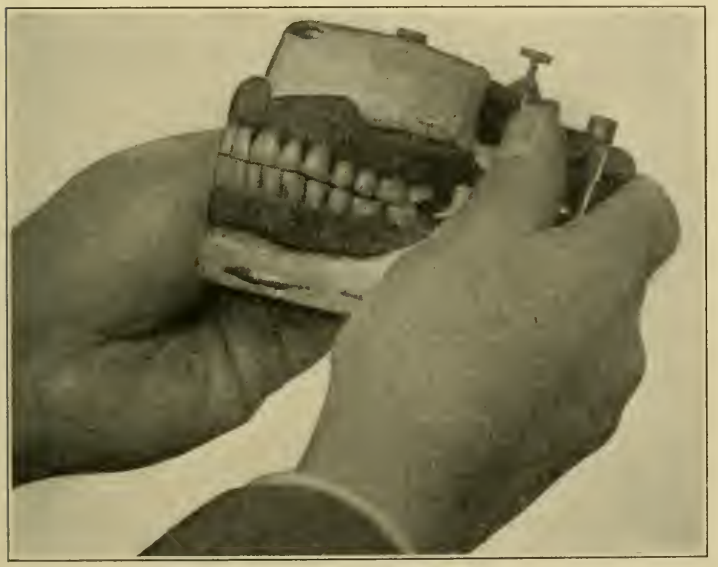
Having developed the philosophy of this peculiar arrangement of these three molars, a return may be made to the technique.

In like manner the three molars are adjusted on the other side of the case.

Proving the Antagonization.—A critical study should now be made of the antagonization of the teeth as mounted. For this purpose the antagonizor is grasped so that the

thumbs and fingers may manipulate the condyle paths, and the three movements (incisal, right and left lateral) are repeatedly produced. This will disclose any imperfections in the alignment of the teeth. Should any of the teeth prove to be too long and interfere in the varied movements, they may be intruded or ground upon the lathe. The teeth may be ground while mounted in wax, provided light pressure

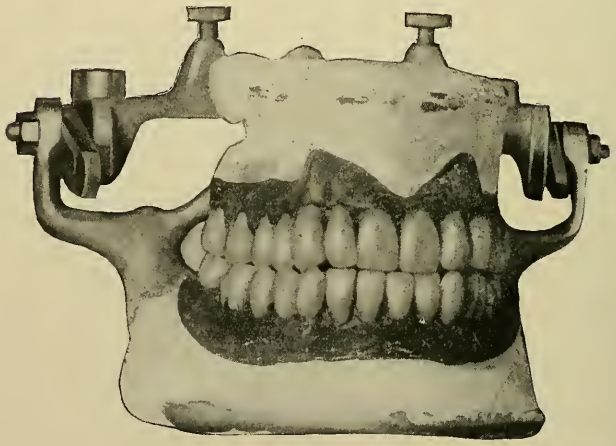
FIG. 152



is used in holding them against the stone, and the stone is *sharp* and *true running*. The requirements of well-antagonized teeth are that there shall be sufficient points of contact in any position in which they may be closed, in ordinary use, to balance them, or to prevent their displacement. If the teeth are placed in incisal occlusion, as shown in Fig. 152, the upper and lower incisors will be in contact, also the upper first molars (disto-occlusal margin) will be in

contact with the lower second molars. It will be only incidental and owing to an irregularity of alignment should there be any points of contact between the incisors and molars, for the upper teeth describe a straight line and the lower, by inclining the second molar, describe a concave line; and a concave line can be in contact with a straight line only at its extremities. The teeth being in right lateral occlusion, that is, the lower carried to the right (Fig. 153), there will be many points of contact on the right side but

Fig. 153

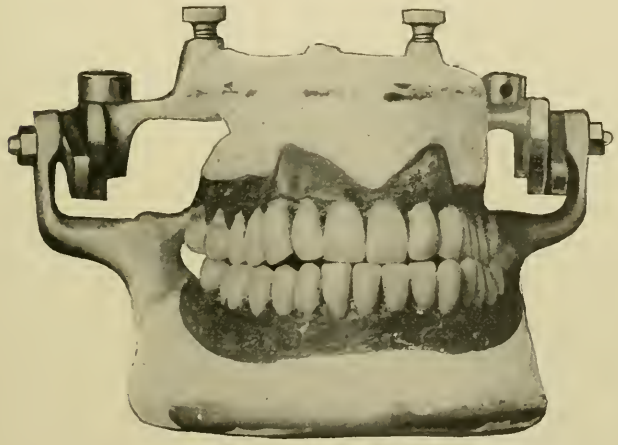


no contact on the left side, except, because of the pivotal movement, the lower second molar is carried forward and is in contact with the disto-occlusal margin of the upper first molar. This gives the so-called three-point contact, as represented by the molars upon the left and the cuspids and molars on the right side. The teeth being placed in the left lateral occlusion (Fig. 154), the same relations are established for that side.

In this critical study of the antagonization of the teeth it should be apparent that there is a relationship between

the lateral inclination of the bicuspids and molars and the angle of the condyle path. The difference in width of the maxillæ and the mandible, in the bicuspid and molar region, necessitates that these teeth are more or less laterally inclined; and that the plane described by the lateral movement varies from straight to sharply concave, with the concavity upward. If the condyle path is horizontal, the lateral movement plane will be straight; but if the condyle path is nearly perpendicular, the lateral movement plane will be sharply concave. This is demonstrated by two blocks

FIG. 154



of plaster mounted in the antagonizor, and the lateral movements made until the blocks are so ground that they will be uniformly in contact at every point, while in the lateral movement. If the teeth have not been correctly inclined while mounting, they may be corrected by softening the wax about the cervical ends of the teeth with a hot ironing wax spatula and moving the cervical ends either inward or outward as required. It may be necessary to remove certain of the teeth and deepen the sulci and possibly shorten some of the cusps. When the teeth are ground and mounted

so that they may be moved in any direction (three), and not meet with interfering points, also have the largest amount of contact surface, the critical study and correction may be considered as completed. Time used in this critical work is well spent.

To complete the mounting of the teeth sufficient wax is cut away to permit the upper second molars being set in occlusion with the lower second molars, which are fixed in position with melted wax.

It is noticeable in some of the illustrations that there is a space between the lower first and second molars. The reason for this is that by carrying the second molar forward, surface contact cannot be gained, only a V-shaped space formed, while by carrying it backward it affords a longer gliding surface for the upper first molar and a larger contact surface for the upper second molar.

FINISHING THE MODEL DENTURES

The teeth being now accurately mounted and antagonized, care must be exercised not to disturb them in any further manipulation. As the outlines of the wax model bases are the outlines of the finished dentures, attention should be given to the contour of the wax model bases. These are completed by adding wax where there may be a deficiency, cutting away excessive wax and glossing the surface. The Haskell and Gritman spatulas (4 and 5 respectively of Fig. 105) are excellent as ironing instruments, and the Nos. 1 and 2 instruments of the Evans carvers are especially suitable for carving. There are two methods for glossing—(1) heat, and (2) a solvent. The heat may be applied to glossing the surface either by passing the wax model base through the Bunsen flame with a moderately rapid motion; or the flame may be puffed upon the surface of the wax with a small mouth blowpipe. An expert may produce beautiful results with the flame, but the novice is liable to come to grief. The solvent method consists of wiping

the surface over with a soft cloth (quarter of an aseptic napkin) moistened with a wax solvent. The most convenient and least objectionable solvent is chloroform. The teeth are cleansed of wax at the same time that the surface is smoothed. As the surface is covered with partially dissolved wax, the case should be permitted to stand until the chloroform has evaporated. The evaporation may be hastened by using a blast of air.

Proving in the Mouth.—The artificial dentures are now ready for the third appointment with the patient. There are two phases of constructing artificial dentures to be given consideration at this sitting of the patient—(1) proving the occlusion and antagonization, and (2) developing the esthetics.

Proving the occlusion and antagonization is accomplished by placing the well-cooled model dentures in the mouth and requesting the patient to close the "back teeth," but force should not be used upon them, as they are only in wax. If they close in the retruded position, as constructed upon the antagonizer, the inference is that the occlusion is correct. However, it is well to make other tests, as there is nothing about prosthetic dentistry quite so uncertain as how an edentulous patient may close the mouth. They are more liable to close it in a protruded position than in the normal retruded one. As a further test, the head is tilted backward, the prosthetist parts the lips slightly, and watches the result while the patient performs the act of deglutition. This act will necessitate the mandible being in its normal retruded position. Should the mandible drop backward an eighth or a quarter of an inch, the student may feel momentarily disheartened, for it will be necessary to go back and do the work all over again, beginning with the paraffin base-plates and occlusion and contour models. However, the student will profit by such an experience and henceforth give more attention to his occlusion and contour models. Should the deglutition test prove the occlusion in retrusion to be correct, the test for *equalized pressure* is applied. Before making this test it is better, as the wax has been absorbing

considerable heat, to remove the model dentures from the mouth and again coil them. They are replaced in the mouth and just firmly held in retruded occlusion. An attempt is made to insert a thin-bladed spatula between the bicuspids and molars upon first one side and then the other. Should the pressure be even upon the two sides, well and good; but should there be a separation on one side, admitting the blade of the spatula, the blade should be rotated to determine the extent of the imperfection. If the imperfection is but slight, it may be corrected by removing the model dentures from the mouth, placing one in water to cool, drying the wax of the other (with absorbent cloth) about the non-contact teeth, softening the wax, extruding the teeth, and adding melted wax as indicated. The model dentures are returned to the mouth and closure made until equal pressure is obtained upon both sides. Should the separation upon one side be extreme, it is past correcting, and necessitates returning to the casts and beginning again. As the novice learns by experience, he will see that equalized pressure is an absolute necessity in the occlusion and contour models, and this prevents the unequal pressure in the model dentures.

The model dentures, meeting the tests applied for retruded occlusion and equalized pressure, are placed in incisal occlusion and tested with the thin spatula for equal pressure at the three points of contact. The dentures are then consecutively placed in right and left lateral occlusion and tested with the spatula. The dentures meeting these tests are removed from the mouth, laved in cold water, dried, and returned to the antagonizor. As slight imperfections of occlusion and antagonization will be unconsciously corrected in the mouth, and may be apparent upon the antagonizor, it will be necessary to bring the antagonizor to the proved model dentures, and not the dentures to the antagonizor. The antagonizor is conformed to the tested model dentures in this manner. The upper cast is removed from the antagonizor, the model dentures and upper casts are assembled upon the lower cast, and the upper bow again attached to the cast with

plaster. However, it is not necessary to conform the antagonizor to the tested model dentures unless it is desirable to make changes for cosmetic effects; then it is well to have a fixed record of the antagonization as developed in the mouth. It should be evident to the student that if all the procedures have been faultlessly performed up to the mouth test, no corrections will be necessary; but as there are so many sources for error, it is necessary for the most experienced and skilful prosthetist to prove the work at this stage of construction.

The second object of the third appointment is to develop the esthetics. This phase of the subject will be fully treated in the chapter on esthetics. The design in this chapter is to treat only the art and the science of construction.

CONVERTING THE MODEL BASE INTO VULCANITE

The model dentures having been perfected are ready to be converted into their permanent form. This consists of substituting vulcanite for the wax. This conversion requires good workmanship and involves considerable science.

Synopsis.—Luting the model dentures to the casts; removing from antagonizor; flasking; opening flask; removing wax; heating; packing; closing flask; vulcanizing; removing from vulcanizer and flask; finishing.

Luting.—The model dentures are luted to the plaster casts by running a hot wax spatula (Fig. 105) along the peripheral border. It is essential to have the entire border luted so as to prevent the soft flasking plaster from getting between the model dentures and casts.

Removing from Antagonizor.—The bows holding the casts are removed from the antagonizor frame. The plaster cast is removed from the bow by soaking in water for a minute or two, trimming away any luting plaster that may overlap the cast, forming a notch between the cast and luting, inserting a plaster spatula in the notch, and tapping with a light hammer.

Flasking.—The cast with its luted model denture is then adjusted to the vulcanite flask. The adjustment consists

in seeing that the cast is neither too thick nor too wide for the flask; if such is the case, the cast must be reduced. This is done with a plaster knife (Fig. 62), after soaking the cast in water. Sufficient soft mixed plaster is placed in the lower half of the flask to fill it half full. The cast is then pressed into the soft plaster a sufficient depth to permit of the teeth being clear of the cover when the ring and cover are in place. Plaster is added to fill the space between the edge of the base of the flask and the periphery of the model denture. The plaster must not be carried upon the model denture. When the plaster has set it is trimmed smooth with the plaster knife. Fig. 155 shows the case properly

Fig. 155

enclosed in the first section of the flask. The plaster being set and trimmed so that no portion overlaps the rim of the flask, a slope extending from the model denture to the rim of the flask, and care exercised that no form is given to the plaster to act as a key and thus interlock the two sections of the flask, the exposed surface of plaster is varnished with sandarac as a separator.

Flasking Upper Section.—As soon as the varnish has dried the surface of the porcelain teeth and wax model base is wetted by holding in running water; this will favor the plaster flowing smoothly over the surface and filling the interspaces between the teeth. The model denture being wetted, the ring of the flask is set in place and a thick creamy mix of

plaster of Paris is poured in to nearly half fill it; the base and ring of the flask are so grasped as to hold them together while jarring on the bench, thus causing the plaster to settle into every interspace between the teeth. More plaster is added and settled in place by jarring. The third addition of plaster should fill the ring when the cover is placed and firmly pressed with the fingers, thus forcing out any excess plaster, which is wiped away.

Opening the Flask.—The filled flask should stand until the plaster is hard set (thirty minutes). It is then placed in a three-quart stew pan and covered with cold water. The pan is placed upon the gas stove or large laboratory heater and heated until the water begins to boil, when the flask is removed from the water (use flask tongs, Fig. 122, or holder of Buffalo No. 2 press, Fig. 113) and held in the left hand protected with a cloth holder. Start the separation of the two sections of the flask by inserting the edge of a plaster knife between them. As soon as the two sections loosen, the upper section is grasped with a cloth holder and carefully drawn apart, care being exercised to so manipulate the two sections as to release them of any slight interlocking. The rule for placing the knife for starting the separation is: For upper cases place the knife at the heel of the flask, and for lower cases at the toe of the flask. This will prevent fracturing the overhanging anterior alveolar ridge.

The instruction given for heating in water is subject to much variation. The object is to apply heat in such a way as to soften the wax without melting it. It is evident that some judgment is necessary, as there are several factors, such as amount of heat, water, and plaster about the wax. A little experience and observation will enable the prosthetist to closely estimate the time to open the flask.

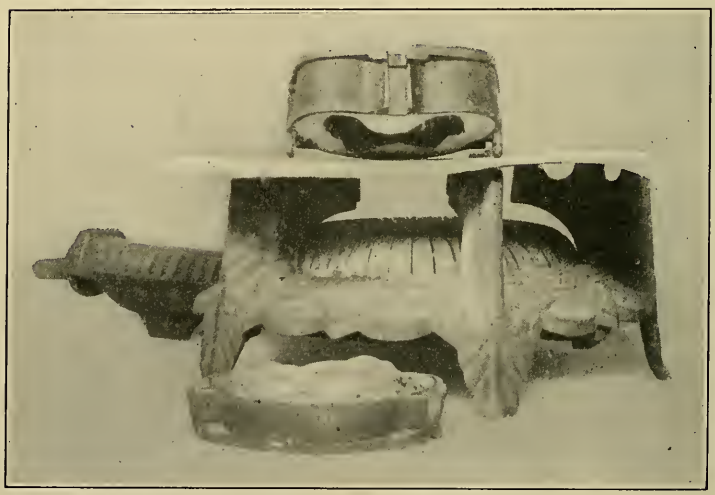
Another method is to have the water boiling and submerge the flask for three to seven minutes. The time is inversely to the thickness of the encasing plaster about the wax.

Removing Wax.—The softened wax is removed from the parted flask with a wax spatula so far as possible, and the remainder removed by a stream of boiling water. (A small

teakettle is excellent for this purpose.) By examining the parted flask it will be seen that the cast is in the bottom section of the flask, and the teeth, with their cervical ends exposed, are in the upper section. If any plaster has found its way about the pins and cervical ends of the teeth, where there should be none, it should be removed with a pointed instrument and brush.

Heating.—The upper section of the flask is placed upon an 8 or 10 inch square piece of sheet iron over the gas stove,

Fig. 156



as shown in Fig. 156. While inspecting the upper section of the flask the lower section is placed under the sheet iron, as seen in Fig. 156, to be dried by reflected heat. During the three or four minutes that the upper section is warming, the surface of the cast in the lower section of the flask is given attention. The surface of the cast should be treated so that it will impart a dense and smooth surface to the vulcanite. There are two methods for accomplishing this—(1) painting the surface with a liquid finish, and (2) covering with tinfoil.

The Silex Method.—The liquid silex method has the advantage of being easily applied, and if the surface of the cast is entirely free of wax or oily substances, will give good results. A clean ox-hair or camel's-hair brush is dipped into the liquid silex and is then applied to the cast. It will be necessary to occasionally dip the brush into water, so that the silex may be well diluted and evenly applied. The excess silex should be absorbed with a cloth. Another method is as follows: While the thin silex is still moist upon the cast, dust with talcum powder, and, when dry, rub carefully with a soft cloth. Liquid silex acts better on plaster of Paris casts than on Spence plaster compound casts. The liquid silex bottle should be kept well corked and no particles of plaster be permitted to get into it, as they will precipitate and spoil the silex for its intended use. The brush must be well washed each time it is used.

The Tin Method.—This method is preferable because it gives a smoother and denser surface to the vulcanite, especially if any wax has been melted into the cast. A sheet of No. 6 or 8 tinfoil is fitted over the cast with the thumb and finger. It is then removed and the excess tin cut away with sharp scissors, as indicated by the imprint of the edge of the cast upon the tin. The cast is now coated with sandarac varnish, and the tin is at once replaced and firmly pressed and gently rubbed with a wad of soft paper until there is perfect adaptation to the cast. The tin should be rubbed until it has a well-burnished surface. It is important that the tinned cast be coated with a lather of soap. This is accomplished by wetting a soft bristle brush and rubbing it upon a cake of soap and then upon the palm of the hand until a smooth lather is formed, which is applied to the tinned surface; or, a thin wash of Johnson's ethereal soap may be used. If the soap is not applied the tin and vulcanite will adhere very strongly, and can only be separated by dissolving the tin with mercury or hydrochloric acid.

The cast, having been coated with either silex or tinfoil, is replaced under the sheet iron to be warmed while packing the rubber into the upper section of the flask.

Packing the Rubber.—During the time the flask is being heated preparatory to separating, the rubber is stripped of its cloth covering and cut into suitable form for packing. For the upper case a piece of red rubber is cut of sufficient size to cover the central portion between the teeth; and the remainder of the red rubber, required for either the upper or lower, is cut into strips, across the sheet, about one-half inch wide. Sufficient pink rubber, or Walker's granular gum, to face the labial and buccal surfaces of the case is cut into the same sized strips, also thirteen small pieces (triangle or square, form indifferent, size about one-fourth inch) are cut for packing between the teeth. For convenience of handling, the cut rubber may be placed upon a porcelain plate or a piece of glass. As rubber is very cohesive, the pieces must not touch each other while on the receptacle. As the flask is heated, it is unnecessary to heat the rubber; in fact, the cold rubber can be much more conveniently handled than that which is warm and adhesive. The heat of the flask will sufficiently soften the rubber to cause it to pack easily. Care should be exercised not to overheat the flask. It should be about the temperature of boiling water, or lower. As rubber melts at 250° F., and its quality is impaired when melted if exposed to air, it is well to have a safe margin of 40° or 50°. Two instruments, one in each hand, will be required for packing the rubber. Any small and blunt instrument may be used. A small flat-blade burnisher held in the left hand to stay the rubber while packing, also useful to carry the small pieces between the ends of the teeth, and the No. 3 instrument of the Evans set (Fig. 104) are admirably adapted as packing instruments. A narrow strip of red rubber is placed along the pins of the teeth, and as the rubber softens is pressed against the pin with the flat side of the broad end of the No. 3 instrument. The pins of all the teeth being engaged in the red rubber, one of the small pieces of pink rubber is engaged in each of the spaces between the ends of the teeth. Packing these small pieces is simple and expeditious; however, a novice is liable to waste much valuable time in its performance. The

small pieces of rubber are carried on the pointed end of the No. 3 instrument to place, the edge of the burnisher, held in the left hand, carries it between the teeth, and while so held the No. 3 instrument is used to turn one edge over upon the centre of the space between the teeth and compress the rubber while withdrawing the other instrument. These three movements to each space should be sufficient. A strip of the pink rubber, sufficiently wide to nearly cover the buccal and labial surfaces of the denture, is placed with one edge overlapping the teeth for about one-half their thickness. The fingers are then used to compress the strip of rubber down upon the ends of the teeth and against the sides of the plaster mold. This act unites the large strip and the small pieces and perfectly forms them about the cervical ends of the teeth. If much restoration is required for the gum portion, another layer of pink rubber may be placed upon the adjusted piece. However, the edge of this piece should not overlap the teeth, but extend from the teeth to the margin of the mold. If there is great thickness of gum restoration required, pink rubber should be added to nearly complete it. The reason for making heavy restorations with pink rubber in place of the stronger red rubber is: There is no danger of thick masses of pink rubber vulcanizing porous, while the same space filled with red rubber is almost certain to do so. If a thin gum restoration is required, one layer of pink is sufficient. The next step in packing the upper case is to place the centre piece, which is done by adapting the piece of rubber to the plaster matrix by finger pressure, from the centre outward, permitting the edge to overlap the packed rubber. In the lower case one or two thicknesses of red rubber is placed upon the lingual surface of the mold. The packing of rubber is done with the fingers when possible, only using instruments where the fingers cannot effectively reach. The problem confronting the workman at this stage of the operation is to know when sufficient rubber has been placed to just fill the mold, for much excess rubber is liable to do harm. Various methods are used, as: Weighing the wax model plate and taking its

weight plus one-fifth in rubber, the difference in specific gravity. Displacement method: Place the wax model plate in a suitable dish (glass tumbler) and fill it to overflowing with water; the wax is removed and replaced with rubber. With either of these methods a little extra rubber should be added and good judgment used in distributing the rubber in packing. The preferred method is the "Trial" method.

Closing the Flask.—This (trial) method consists of placing the rubber in the mold as has been described, until the judgment dictates there is nearly but not enough to fill the mold. A piece of close woven cotton cloth free from starch is saturated with water (preferably hot) and placed over the packed rubber, the two sections of the flask are put together and carefully closed in the flask press. The flask is then opened and the cloth removed, when it will be apparent where more rubber is required and the quantity. Should so large a quantity of rubber be required that it is questionable when a sufficiency has been added, a trial with the wet cloth may again be made. When the mold is found to be full, the flask is closed without the cloth. (The cloth stripped from the rubber and washed of its starch may be used, but silesia cut in pieces 3 by $3\frac{1}{2}$ inches is better and saves valuable time. Should the cloth, for any reason, adhere to the rubber, saturate it with hot water, when they may be easily parted.) Attention has been called (page 204) to the danger of warping the denture by improper placing of the rubber and heavy pressure in the press. Should the rubber in the mold become too cold, it may be warmed by reflected heat under the sheet iron. In no case should the rubber-packed flask be put in water and boiled before the final compression in the press, as the softening that takes place in the saturated plaster favors warping the denture. Undoubtedly the "fit" of more artificial dentures is impaired by improper packing and closing the flask than by all other causes. The flask being closed is bolted or placed in a Donham clamp (Fig. 109).

Vulcanizing.— For convenience, cleanliness, and uniformity of results, dental vulcanization is accomplished in a specially constructed machine called a vulcanizer (Fig. 121), which is a steam-tight boiler. The operation can be accomplished in a sand, glycerin, or oil bath, but this is not desirable for obvious reasons. The time of vulcanizing will be influenced by both temperature and the surrounding medium. Vulcanization begins at 248° F., but at that temperature it would require many hours; at 280° F., it will require five and one-half hours; at 300° F., two and one-half hours; and at 320° F., fifty minutes. The medium surrounding the flask in the vulcanizer must be either water, steam, or air. The time required to produce the same results will be in inverse ratio to the conducting power of the medium; water, being the best conductor of heat, will require the least time, steam second, and air, being the poorest conductor, will require the longest time. The vulcanizing process consists of causing the mechanical mixture of caoutchouc gum and sulphur to combine chemically. This is accomplished by the action of heat. As there are various compounds formed, varying from $C_{100}H_{160}S$, for the lowest combination, to $C_{10}H_{16}S_2$, as the highest, it is evident that the degree of heat and the length of time the heat is applied are the essential factors in producing these compounds; and as there are two chemical processes going on, the addition and the substitution, the manner of the application of the two factors will determine the quality of the product produced. The evolution of gas, H_2S (see page 196), may do much harm if not properly controlled. Therefore it is evident that the best conductor of heat (water) will give the most equitable temperature and is the preferred medium; and that the temperature and time should be governed by the thickness of the mass of rubber to be converted into vulcanite. A thin sheet of rubber may be vulcanized rapidly, that is, at a high temperature (320° F.) and short time, that is, eighty minutes—thirty minutes to "heat up," and that temperature maintained for fifty minutes. Rubber one-fourth inch thick may be heated to 300° F. in thirty minutes and maintained

at that temperature for two and one-half hours. A mass of rubber one-half inch thick should not be heated above 280° F., but that temperature should be maintained for six hours. Therefore a good rule is: Thin pieces of rubber, as base-plates, vulcanize at 320° F., time eighty minutes; thick cases, temperature 300° F., time three hours. However, with thick cases the temperature may be raised and the time shortened by using pink rubber (because of its contained earthy matter) upon a thin sheet of red or black rubber.

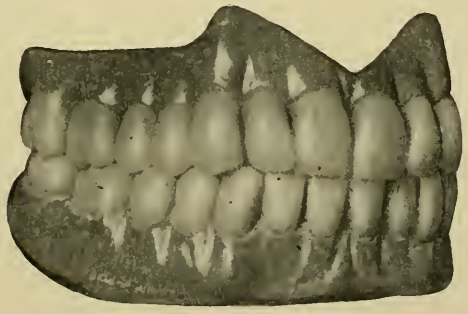
Removing from the Vulcanizer.—It is always best to permit the vulcanizer to stand until it is cold before opening, but when it is necessary to expedite matters, the steam may be blown off, the vulcanizer opened, and the flask submerged in a pan of cold water. This last procedure would be condemned by some, but owing to the poor conducting and radiating property of plaster, it is doubtful if this method of cooling ever accounts for fractured teeth.

Removing from the Flask.—Under no conditions, however, should the flask be opened until the plaster in the centre of the flask is cooled to blood heat, which will be some time after the flask is cold if placed in water. The flask is released of its clamp or bolts, held in the left hand, with the plaster knife in the right hand. The knife, guarded with the thumb so that only a quarter or half-inch is exposed, is used as a wedge to part the sections of the flask. Usually the case will remain in the ring portion of the flask, and is removed by cutting a groove in the encasing plaster between the denture and ring. The plaster both on the inside and outside of the denture is grooved and removed in sections, thus avoiding the danger of fracturing the denture. The last portions of the plaster not easily removed with the knife are removed by scrubbing with a stiff bristle laboratory brush and water.

Finishing.—The edges of the denture as it comes from the flask are rough and irregular from the extension of excess vulcanite. This is removed with a rather coarse file specially made for this work (Fig. 123). A seven or eight inch half-round file, having an oval and a flat side, a coarse and a fine end, is a very desirable instrument. The cutting

is done with a push stroke. A round or rat-tail file is also very useful. For scraping the surfaces the No. 1 short shank Kingsley scraper of the Wilson vulcanite finishers is used. The No. 4 instrument is useful for small places, and especially for removing defects on the maxillary and mandibular surfaces. The chisel (No. 2 of this set) is for carving about the teeth, and the pick (No. 3) is for working between the teeth (Fig. 124). These instruments should be kept very sharp by grinding and honing. The entire labial, buccal, and lingual surfaces of both upper and lower dentures are gone over to remove excess material, give form, and to remove the roughness received from the plaster

Fig. 157



matrix. The file and scraper marks are removed with sandpaper. No. $\frac{1}{2}$ for coarse paper and No. 00 for fine paper is cut into two and one-half inch squares, by placing the sand side down over a crevice and cutting with a knife. The sandpaper marks are removed with buffers and glossers (see pages 224 to 229). The maxillary and mandibular surfaces require no finishing except to remove any excrescences formed as a result of air bubbles in the surface of the cast. These are carefully removed with the small scraper. This surface may be more highly glossed by using the soft brush wheel and whiting. The finish grinding (see page 236) of the occlusal surface of the teeth is executed with small stones mounted

on an engine mandrel and carried in the lathe chuck. The object sought is to deepen or reproduce the sulci and grooves, thus forming egdes to cut the food in the process of mastication. The ground surfaces of the porcelain teeth are given their final finish with a piece of No. 00 sandpaper applied with the ball of the thumb. The finishing of any mechanical work is an important item, and in artificial dentures is not only indicative of superior workmanship, but is necessary for cleanliness and health of the tissues with which it will be in contact. Fig. 157 illustrates the completed dentures.

Inserting the Finished Dentures.—The fourth appointment with the patient is a very important one. The dentures are inserted and the adaptation in every respect inspected. The dentures are wonted to their place by closing the teeth and swallowing; this settles and withdraws the air from beneath them. If the dentures are evenly seated, so that pressure may be made upon any part without being disturbed when opening the mouth and by the ordinary movements of the lips and tongue, and do not cause pain, and the occlusion and antagonization are correct, the patient should be instructed how to use and cleanse them. The patient should be instructed to keep the dentures in night and day, only removing for cleansing, until they have become masters of the artificial substitutes, after which the dentures should be removed at night, cleansed, and kept in a weak solution of boracic acid. The patient should be instructed that if the dentures cause pain, they are not to be removed, but that the patient is to return to the office for attention.

THE CONSTRUCTION OF EITHER AN UPPER OR LOWER DENTURE

The technique involved in the construction of either an upper or lower denture varies from that of both upper and lower in a few of the processes. As the technique for constructing an upper denture to natural lower teeth is the same

as constructing a lower denture to natural upper teeth, or *vice versa*, it is necessary to describe but one, as the description of either would be the same as the other except in the use of the terms upper and lower, which would be transposed. For convenience of description the imaginary patient has an edentulous upper jaw with a full complement of normally aligned lower teeth.

The mouth is carefully examined and the conditions observed. A scheme is devised for taking the impression according to the indications, a suitable cast and the upper occlusion and contour model formed. The processes of construction are the same as described for the complete upper and lower case up to forming the occlusal surface of the wax model. As in the former case, the occlusal surface of the anterior portion of the model must mark the length of the upper lip when at rest and relaxed. The occlusal surface of the model as it extends backward must have at least three widely separated points of contact with the lower teeth. The patient is then exercised in the forward and backward or protrusion and retrusion movements of the mandible. The wax model is then removed from the mouth, cooled, and dried. With a roll of soft wax placed upon the occlusal surface of the model, it is returned to the mouth, and the mouth closed in the retruded position, biting the teeth through the soft to the hard wax. The wax model is removed from the mouth and a wax impression taken of the lower teeth. The imprint of the lower teeth in the wax model will not suffice for the impression. The wax impression is taken by placing a roll of well-softened yellow wax in a warmed, suitable size, flat floor lower tray. A good impression should be obtained of the occlusal surfaces and at least one-half of the length of the teeth. The impression of the cervical half of the teeth is indifferent. The impression is filled with plaster or, better, Spence compound. When the plaster is hard set, the tray is removed by warming in the Bunsen flame and lifting it away from the wax. The wax will be somewhat softened in removing the tray, and may be further softened by passing through the flame. It is

removed from the cast by turning the buccal and labial surfaces of the wax upward and inward to the lingual side, when it may be easily removed from the cast. The upper cast, wax occlusion model, and lower cast are then assembled and mounted upon an occlusion frame or an antagonizor to be used as an occlusion frame. The student should be impressed with the fact that the casts so mounted are in no way to have their relationship changed without removing from the frame and remounting. It is hardly necessary to use a face bow in mounting a single case upon an antagonizor, as the occlusion is established, and, except in rare cases, it is not justifiable to alter these natural teeth. However, the face bow may be used if desired, in the same manner as for the full upper and lower dentures. A case so mounted permits of opening or closing the bite, but this will not be necessary if proper attention was given to forming the wax model. Then, again, if the case is mounted with the face bow, interfering cusps may be more easily detected.

The teeth must be ground and set up so that the molars and biscuspids intercuspate and the six anterior teeth are free of contact. As it is a rare instance that a full upper denture will be required and the patient have a full set of normally aligned natural lower teeth, it becomes necessary to give special attention to the occlusion. The law of force and the law of the resultant of two or more forces must be taken into consideration, or the completed denture will be very deficient. The rule is to have the force or the resultant of two forces act at right angles to the normal occlusal plane. However, it is permissible and often desirable to have the line of force, acting upon a full upper artificial denture, slightly distal to the perpendicular. This is accomplished by having a greater stress upon the mesial than upon the distal facets of the upper teeth. The teeth being properly occluded (leaving the antagonization to be attended to at the time of fitting in the denture), the construction is completed the same as in the case previously described.

PARTIAL DENTURES ON VULCANITE BASE

It is a truism that the difficulties of constructing artificial dentures are in direct ratio to the number of teeth to be supplied. The technique of constructing a partial vulcanite denture for either jaw is the simplest prosthetic procedure (however, the fitting in or adjusting to the mouth is more difficult than any other vulcanite denture); either a full upper or lower is more complicated, while the complete upper and lower present the greatest problems of prosthesis.

A perfect plaster impression (see Chapter II) should be obtained to enclose a little larger surface than the base-plate is designed to cover. Usually an occlusion cast of the opposite teeth is required; however, if there are no opposing teeth an occlusion cast will not be necessary. In some partial cases the two casts will have so many points of contact that they may be assembled without further aids. A quash-bite will suffice for some cases, while for others a well-constructed occlusion wax model may be a necessity. The case is placed in an occlusion frame, a wax base-plate formed, teeth of color, form, and size to correspond with the remaining teeth in the mouth are selected. They may be ground to favor adjustment, also to obtain the required occlusion. It is rarely necessary or advisable to try a partial model artificial denture in the mouth. The wax model plate being contoured, the cast containing it is removed from the occlusion frame. The rule for flasking full cases is: The separation of the two sections should be at the peripheral edge of the wax model plate. This rule applies to some partial cases. In these cases the plaster teeth should be cut down flush with the wax model plate and the encasing plaster built up to the top of the stumps of the plaster teeth. These reënforced stumps must be so shaped that they will easily draw from the mortise they form in the upper section of the flask. There are many partial cases in which the porcelain and plaster teeth so alternate that it is better to encase the teeth in the first section of the flask. It is obvious that the packing

of such a case must be from the lingual aspect. Fig. 158 illustrates an upper model denture without labial gum

Fig. 158

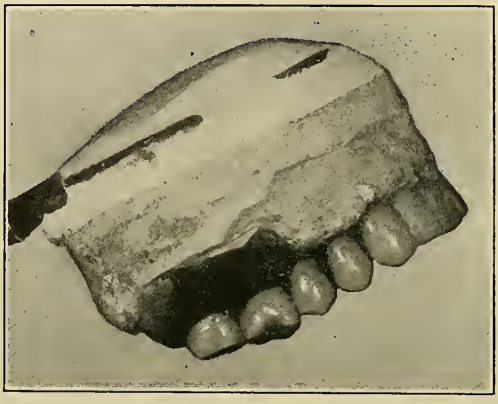


Fig. 159

restoration. Fig. 159 is the case in the first section of the flask.

The tinfoil used to finish the maxillary or mandibular surface is applied before placing the base-plate wax, because it will be difficult to adapt the foil in the flask. The soap solution is applied after the wax is removed, just prior to packing. Careful manipulation will be required in the various procedures not to disturb the finishing tin. The liquid silex method is useful in many partial cases.

Most partial cases may be vulcanized at the high temperature (320° F.) and the short time, because of the small amount of rubber.

Care should especially be exercised, in removing the case from the flask, to have the plaster cold, and in the use of force.

The finishing process consists of filing, sandpapering, buffing, and glossing, and are essentially the same as for full cases.

Adapting the finished cases to the mouth is, as has been stated, a difficult and often a perplexing operation. It will frequently require careful study and manipulation, and often much trimming away of the base-plate as formed. However, this trimming must be judiciously performed, because as close an adaptation and as large a base of support as possible is imperative. Partial cases may require a high degree of mechanical ability, but complete dentures will require mechanical dexterity and esthetic sense.

The retention of artificial dentures has not been mentioned in discussing the technique of vulcanite construction, for the subject is more comprehensible when considered in the abstract.

REMOVING THE TEETH FROM A VULCANITE BASE-PLATE

Sheet Iron Method.—Place the denture, teeth downward, upon the sheet iron over a gas stove, and when the vulcanite is thoroughly softened, the teeth may be pushed off one at a time by inserting the wax spatula between the tooth and

the vulcanite upon the lingual side. The plate is held by a pair of pliers and the dislodged teeth are permitted to fall upon wood, or better, upon cloth, but not upon cold iron or stone. Any portion of the vulcanite remaining about the pins should be removed. If necessary, these small portions of vulcanite may be softened by grasping the tooth in a pair of solder tweezers and holding in the Bunsen flame.

Glycerin Method.—The denture is placed in a vessel of glycerin and heated to the boiling point of the liquid, when the teeth can be removed as in the other method. The glycerin is soluble in water and easily removed. The fumes of the heated glycerin are more objectionable to some than those of the overheated rubber.

Flame Method.—The denture is grasped with a pair of pliers and the outer surface of the teeth heated by passing repeatedly through the flame until the vulcanite is softened about the pins, when they are removed as before described.

It is not advisable to remove the teeth by heat from a denture which is to be used again, because of the liability of warping the plate. In such cases the vulcanite should be cut from about the pins of the tooth with a bur in the engine, or with a chisel.

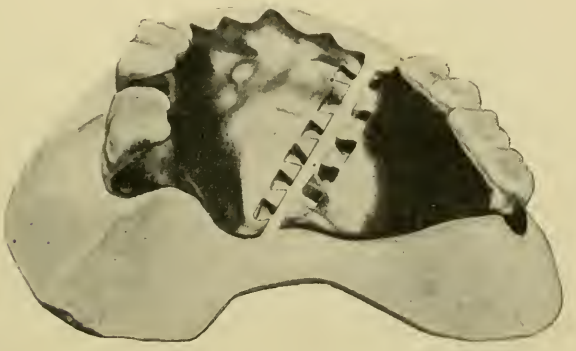
REPAIRING VULCANITE DENTURES

The breaking of vulcanite dentures is usually due to over-vulcanizing, by which elasticity and toughness are destroyed; to improper arrangement of the molars, by which the strain of mastication is thrown on the outside instead of on top of the ridge; or to a warped plate. The first evidence of the giving way of a piece is usually a fine crack appearing between the two central incisors, and sometimes, in partial dentures, in the border surrounding a natural tooth.

Wax Method.—A method particularly applicable to plates which are broken entirely in two, consists in adjusting the two parts of the plate together, and fastening them in correct relation to each other temporarily by adhesive wax dropped

on the lingual surface until plaster can be run into the maxillary portion of the denture. As soon as the plaster hardens, the plate is removed from the cast, the line of division is enlarged with a file, and dovetails cut opposite each other with a jeweller's saw, as shown by Fig. 160. The dovetailed space is then filled with wax, invested in the usual way in a flask, packed, and vulcanized. By another method the edges may be adjusted as before described, and the piece be placed immediately in the lower half of the flask. After the plaster has set, the adhesive wax is to be removed from the lingual side of the plate and a line cut with a round

FIG. 160



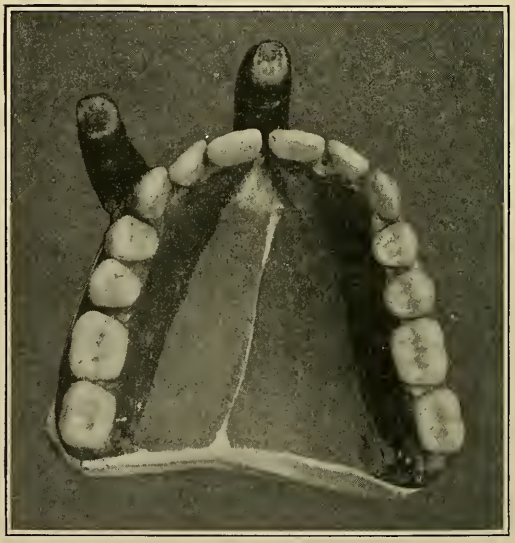
engine bur along the full extent of the crack, or break, half-way through the plate and a quarter of an inch wide, with smooth regular edges, without dovetails. The case is then waxed up and the other half of the flask poured, when the case is packed and vulcanized. If the parts have been kept perfectly clean, the union will be quite strong.

Another modification,[1] which gives the best results, is this: After the cast is made, the portions of the plate are removed from the cast and with file and scraper a long bevel is cut, forming a thin feathery edge along the fractured

[1] The method preferred by the writer.

edge and sloping away from this for an eighth to one-half inch as the case will permit (Fig. 161). The pieces are then filed to give a slight bevel upon the maxillary surface. The portions of the plate which have been cut away are replaced with wax, and if necessary the plate may be thickened over the portion having the freshly cut surface. It is unnecessary

Fig. 161

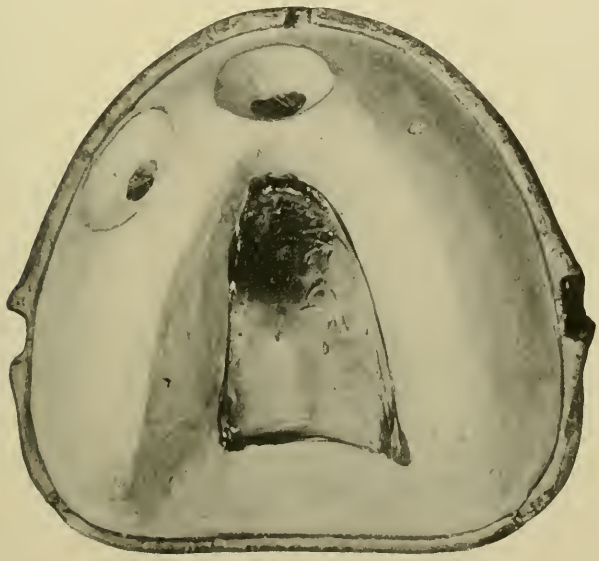


to coat the vulcanite surface with a solution of rubber, as the heat and pressure will make the union. Fig. 162 shows method of flasking.

In this connection, attention is called to a class of repair cases that perplex the novice; namely, those having an extensive fracture upon both the lingual and buccal or labial surfaces. This difficulty in flasking is overcome by attaching one or more shafts of wax, one-fourth inch in diameter, at suitable locations over the fracture upon the labial or buccal surface. The shaft of wax must be sufficiently long to

extend through the investing plaster. When the plaster has hardened, a portion of the wax shaft and the surrounding plaster is cut away to form a cone-shaped depression, which will be filled in with the plaster in the top section of the flask. These wax shafts will form openings through which the rubber can be packed, and which are to be filled with rubber. After vulcanization the shaft of rubber may be removed with a mechanical saw (Figs. 161 and 162).

FIG. 162



Fusible Metal Method.—To avoid loss of strength by the second vulcanizing it is recommended that fusible metal, melting at 150° to 160° F., be used to fill the dovetail space. This can be done by pouring the melted alloy into the space and packing it with a hot spatula, which is readily admissible owing to the low fusing-point of the metal. While the method has the advantage of not requiring a second vul-

canizing, the union of the metal at the point of fracture is not as close as when rubber is used, and it cannot be said to be reliable as a means of repairing broken vulcanite plates.

A single tooth may be fastened to the vulcanite by filing the dovetailed space as for repairing with rubber, the fusible metal to be put in place with a hot spatula; or the dovetail can be filled with amalgam.

Replacing Vulcanite Method.—Much the better way is to fasten the parts together, run a plaster cast into the denture, then make a bite of plaster to serve as a guide for the replacement of the teeth, remove the latter from the broken plate, reset them to the cast, wax up the piece, flask, and vulcanize. This affords practically a new case, and the time consumed is not much greater than is required in repairing the old one.

FIG. 163

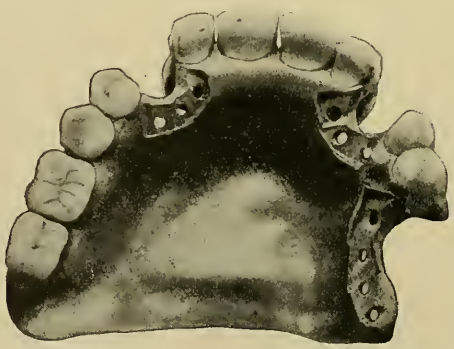


Plate prepared for the addition of several teeth.

Additions to Old Plates.—Additions of teeth to old plates are accomplished after practically the same methods. Fig. 163 shows a case where six teeth have been extracted, and the old plate is prepared for the addition of as many porcelain teeth, so that the denture could be worn until the resorption of the alveoli and gums would admit of the construction of a permanent plate. The illustration shows the plate bevelled off to a smooth edge, and several holes

drilled into the filed portion. The correct occlusion of the new teeth is obtained by placing the plate in the mouth after the bleeding ceases, placing two pieces of softened wax along the alveolar ridge and plate, and directing the patient to bite into the wax, and then gently pressing the wax while the teeth are in contact. This gives the correct relation of the lower to the upper teeth, and the impression of that portion of the alveolar ridge to be covered by the addition to the plate. The preparation of the plaster cast and bite is done in the usual way, plain teeth being ground to the gums to allow for the rapid resorption which always follows the extraction of teeth. The waxing and flasking are done in the usual way.

Ironing-in Method.—This method is suitable for replacing a tooth or two, or filling a short crack or a hole. The vulcanite is cut with a file to give a dovetailed form to the space into which a tooth is to be added; and a crack or hole should be prepared for the new rubber with a scraper. The new rubber is ironed into place by using a hot wax spatula and firm pressure.

CHAPTER VII

PRINCIPLES OF RETENTION OF ARTIFICIAL DENTURES

The retention of artificial dentures is purely mechanical, and is based upon the laws of physics. Indirectly, however, the personal equation is an important factor, in that the patient may not be able to control the laws of physics. These vexatious cases are often spoken of as awkward or clumsy, but such patients will eventually succeed in overcoming the difficulties, provided they have sufficient perseverance.

The physical laws that play a more or less important role in the retention of artificial dentures are atmospheric pressure, adhesion by contact, leverage, tensofriction, and cementation. These forces are not equal in value, nor can any one principle be depended upon for retaining a denture. There will be a primary selected to bear the burden, and one or more secondary forces evoked or unwittingly included. These secondary forces may be either positive or negative. Thus atmospheric pressure may be selected as the primary retentive force, but adhesion by contact must be an associate retentive force, whether it be so designed or not, and eventually will entirely take the place of atmospheric pressure in any given case. The principle of leverage is always associated, through antagonization, with whatever may be the primary method selected. This force especially may be considered as positive when the arrangement of the teeth is such that it tends to force the denture more securely to place, and as negative when the arrangement is such that antagonization tends to loosen the denture.

Atmospheric Pressure.—As is well known, atmospheric pressure is the weight of a column of air resting upon an object. The weight of a column of air at the sea level is 14.7

pounds to the square inch, and decreases in ratio to the height above sea level. As this pressure is equal in every direction upon and within the human body, it is not perceptible. Whenever a portion of this column of air is removed from a circumscribed portion of the body, its effect is immediately felt. No substance can be placed between the atmosphere and the surface, or a portion of the surface, of the body, and remove the pressure of the atmosphere from the body, as the intervening substance, being contiguous, would be held against the surface of the body by the full weight of the column of air resting upon it. Thus we may justly conclude that an artificial denture perfectly adjusted to the tissues of the mouth would be retained by the full weight of the column of air, or approximately fifteen pounds for each square inch of surface covered; also that a chamber cut in the maxillary surface of the plate would be a positive detriment, because it would be an air chamber equalizing the column of air upon the external surface of the plate to the extent of the air chamber. However, there is a fatal obstacle to this imaginary retention of an artificial denture, for it is a physical impossibility to exclude the film of air between the soft tissues of the mouth and the hard base-plate except by substituting a fluid for the film of air. By the substitution of this fluid for the film of air the law of hydrostatics is introduced. The law of hydrostatics is, that a pressure placed upon a confined liquid is equal in every direction. Therefore a mechanically perfectly adapted artificial denture having a fluid contact cannot be retained by atmospheric pressure, because the intervening fluid equalizes, within and without, the atmospheric pressure.

Atmospheric pressure *may be utilized* to retain an artificial denture, but through the medium only of a vacuum chamber. Since an absolute vacuum is an impossibility, the amount of retention by atmospheric pressure is contingent upon the square surface of the chamber and the vacuity obtained. To produce any degree of vacuity it is necessary to have the plate surrounding the vacuum cavity perfectly adapted to

the soft tissues. The extent of exhaustion of the air from the chamber is governed by the power of the muscles of the tongue and the ability of the patient to apply them. The exhaustion is produced by forceful swallowing.

Retention by atmospheric pressure can only be temporary, and maintained only so long as there is a partial vacuum. The effect of the vacuum chamber upon the tissues of the mouth is the same as cupping in medical practice. As soon as the atmospheric pressure is reduced upon a circumscribed portion of the body, it acts as an excitant, causing an increased blood pressure in the part, with a temporary swelling, and if continued a proliferation of tissue cells, producing a permanent growth until the chamber is filled. When the chamber is filled by tissue and the fluids of the mouth, atmospheric pressure can no longer exist; the denture is then retained only by adhesion by contact. While the term "suction plate" is not so euphonious as "atmospheric pressure plate," it more nearly expresses the truth without attempting an explanation of how the suction is secured.

As the amount of retention of a vacuum chamber stands in direct ratio to its square surface, so its relative permanence and its injurious effects stand in direct ratio to its depth.

Adhesion by Contact.—This retentive force is often confused with atmospheric pressure, whereas it is an entirely different principle. Atmospheric pressure retention is contingent upon a chamber which is more or less evacuated of air, while adhesion by contact is conditioned by uniform pressure and absolute contact. To comprehend this principle of retention, the molecular forces of attraction and repulsion must be appreciated. These two molecular forces, to a greater or less extent, exist within and between all bodies. In solid matter attraction predominates over repulsion, whereas in liquids the two forces are equal, and in gaseous matter repulsion predominates over attraction. Attraction is always stronger between like atoms than between unlike atoms. (This last fact is beautifully illustrated in the low-fusing alloys composed of tin, lead, bismuth, and cadmium. These metals range in fusing point from 442° F.

to 617° F., yet when they are properly combined they may fuse at 135° F., thus demonstrating that the molecules of these metals create a marked repulsion for each other, and that it takes but a low degree of heat to render attraction and repulsion equal, that is, for the metals to fuse to a liquid state.) When like atoms are brought into atomic relation to each other, they are said to be held together by cohesion; when the interatomic space is exceeded, they can only be held together by adhesion, either by mass attraction or an intervening adhesive substance. Thus, it is apparent that the expression "uniform pressure" and "absolute contact" are misnomers, because absolute contact is an impossibility; but when these terms are used, they signify the closest mechanical contact of the mass, and do not refer to the atom relationships. When masses of matter are brought into mechanical contact and are caused to adhere by a film of non-adhesive fluid, it might be thought that the adhesion is due to the strength of the fluid; but this is not the case, because the thinner the film the greater the adhesion. That this adhesion is not due to atmospheric pressure may be demonstrated by suspending two masses of matter adhering by contact in the chamber of an air pump and exhausting the air, when the adhesion will remain the same or stronger than under normal atmospheric conditions. Therefore, through an understanding of these axioms regarding attraction and repulsion, we can appreciate how artificial dentures are retained by the so-called adhesion by contact.

Leverage.—In mechanics the lever is a rigid bar working upon a pivot. The pivot is called the fulcrum, and the bar is considered as two portions called arms, the one called the power arm and the other the work arm. There are three groups of these factors—fulcrum, power and work arms—called classes. In the first class the fulcrum is between the power and the work, whereas in the second class the work is between the fulcrum and the power; in the third class the power is between the fulcrum and the work. In the retention of artificial dentures the lever of the first class only need be considered, and it is of great importance. This principle

of physics is involved in every case of prosthetic restoration, either in its positive or negative sense, and too often in both. In complete artificial dentures the alveolar ridge constitutes the fulcrum, and the retention of the base-plate, by either atmospheric pressure or adhesion by contact, constitutes the power; the portion of the base-plate upon which these retentive forces exert their influence constitutes the power arm. The teeth form the work arm, and antagonization is the work. In partial artificial dentures the remaining natural teeth and roots may be the fulcrum or even fulcrums.

The law governing the direction of energy should be taken into consideration. The law is: Energy moves in a straight line and at right angles to the surface from which the force emanates. Thus, in the line of energy there may be great resistance, while laterally there would be but slight resistance. (This is well illustrated by two plates of glass held together by adhesion by contact, which will offer much resistance to an effort to pull them directly apart, but only slight resistance to lateral pressure.)

The anatomical relation of the mandible to the maxillæ is a peculiar one, and offers many problems in physics. As resorption of the alveoli progresses, these adverse conditions become exaggerated. Therefore it follows that artificial substitutes should be inserted soon, that is, within a few weeks—two to six—after the removal of the natural teeth. As the resorption of the alveolar processes progresses, the summit of the alveolar ridge of the upper jaw recedes upward and inward, whereas the summit of the alveolar ridge of the mandible recedes downward and outward. Hence, if the artificial teeth are set in the position occupied by the natural teeth, the problems in leverage become very serious. It is apparent that if the upper teeth could be arranged with their buccal surfaces just inside the summit of the alveolar ridge, it would be impossible to dislodge the base-plate by direct occlusion, no matter how hard or circumscribed the bolus of food; but it is not practical to so arrange the teeth; it is desirable, from a mechanical point of view, to approach this condition as nearly as the individual

case will permit. If after the alveoli have thoroughly receded the upper artificial teeth are mounted upon the base-plate in their normal distance from the raphe, the work arm of the lever is relatively much lengthened. Therefore, to overcome this untoward leverage the teeth are drawn in toward the summit of the ridge. There is a limit to the inward drawing of the lingual surface of the teeth, for undue encroaching upon the domain of the tongue will ensue. That this work arm may be still further shortened, the artificial teeth buccolingually are made narrower than normal. As the shortening of a radius shortens the circumference of a circle, it becomes necessary to select artificial bicuspids and molars a little narrower mesiodistally than the natural teeth which they replace. This is but one of the reasons for the reduced size of the grinding teeth. The other reason for reducing the size of these teeth has to do with their power, and should not be discussed together with the principles of retention. It has already been stated that motion—force—moves at right angles to the surface from which the motion emanates, therefore the shaping of the facets of the occlusal surface of the bicuspids and molars is an important factor in the problem of leverage.

CONDITIONS AFFECTING RETENTION OF FULL ARTIFICIAL DENTURES

There are four factors to be considered in the retention of base-plates: Size, that is, the amount of surface covered; soft tissue; fluids of the mouth; and the shape of the portion covered.

Size.—In any given case the amount of retention by adhesion by contact is, like atmospheric pressure, according to the area of the surface (Fig. 164.) Hence, other things being equal, the larger the denture the better the retention.

Soft Tissue.—No one factor has so much to do with retention of artificial dentures as the soft tissues. These may be divided into three classes—muscles and their attach-

ments, submucous tissue, and the mucous membrane. As an axiom, it may be stated that a base-plate cannot rest upon a muscle which impinges upon or draws over the periphery of the plate, as the contractile power of the muscle is greater than the retentive force of adhesion by contact; also of atmospheric pressure. The muscle attachments should always be observed in examining the mouth prior to taking the impression; then, in taking the impression, the muscles should be marked in the impression, so that the

Fig. 164

base-plate may secure a close adaptation about the muscle attachments, and yet not be dislodged thereby. As adhesion by contact is in the ratio to the surface covered, it is apparent that the base-plate should extend as far in every direction as the attachment of the muscles will permit, but not so far that the muscles when placed upon their greatest tension will impinge upon the periphery of the base-plate sufficiently to dislodge it. This may give a very irregular outline, but the proper outlining of the periphery of the base-plate is one of the important operations in adapting artificial

dentures. Beginning in the median line, the labial flange of the upper base-plate should be well cut away for the labial frenum, then gradually ascend to the cuspid eminence, where for cosmetic effects it must be as high as possible. After forming the outline of the cuspid eminence, the border of the flange abruptly drops to accommodate the buccal frenum. The remainder of the border to the tuberosity must be kept as high as the attachment of the buccinator muscle will permit. In passing around the tuberosity, if there be one, the edge of the base-plate must not impinge too much upon the soft tissues. After trimming the base-plate to what seems to be the proper outline, it should be tested by moistening the maxillary surface, placing it in the mouth, and instructing the patient how to exhaust the air from between the base-plate and the soft tissues upon which it rests. The patient should then be requested to vigorously work the muscles of the lip and cheeks, and see if in any way the base-plate may be dislodged. If so, the patient should again attach the base-plate, the operator grasping the lip and cheeks, one portion at a time, between the thumb and finger, and firmly extend the tissues outward and downward until the point or points that are not properly relieved are discovered.

The lower base-plate is of the horseshoe or crescent shape, and necessarily covers much less surface than the upper one; but if the impression is properly taken and the periphery properly adjusted for the muscle attachments, the base-plate can be seated, and sometimes considerable adhesion obtained. Some writers would lead one to believe that all lower artificial dentures should have a deep lingual flange, while other writers would have the lingual flange almost entirely removed. Both are correct, because some cases require the one treatment and other cases the other method. In those cases in which the crest of the alveolar process of the mandible is pronounced, and the attachment of the mylohyoid muscle is low upon the lingual wall, the lingual flange of the base-plate can and should be carried well down, for adhesion by contact is according to the area

of the surface, and the larger the base-plate the greater the resistance to the force of mastication; but if there is excessive resorption of the process, and the attachment of the mylohyoid is at or very near the crest of the slight ridge remaining, or if there is a sharp edge representing the union of the lingual plate of the mandible and the remains of the alveolar process, there should be almost no lingual flange to the base-plate. If in taking the impression the mylohyoid is compressed and depressed, the apparent space for a lingual flange will prove very delusive and troublesome; also, if the base-plate is carried over the sharp lingual edge often found upon the mandible, much irritation will be produced. In these cases the only means of success is to cut away the lingual flange, if one has been formed. In constructing the superstructure upon this properly fitted short lingual flanged base-plate, an extra retention flange of one-sixteenth to three-sixteenths of an inch in width may be extended horizontally into the mouth, when the glands and folds of mucous membranes resting upon this enlarged base-plate will often be of much aid in retention. The buccal flange should be kept as broad as the muscle attachments will permit. The same tests applied to the upper base-plates should be used with the lower.

Submucous Tissue.—In this class is included all the soft tissue of whatever histological formation—except the muscle tissue just considered—lying beneath the mucous membrane upon which the base-plate rests. When a moderate amount of soft tissue is evenly disposed beneath the mucous membrane, the very best condition possible so far as this tissue is concerned is presented. In some mouths the raphe of the maxillæ will be found overdeveloped and covered with a thin, tensely drawn mucous membrane, while upon either side there may be an area extending well toward the base of the alveolar process with more or less submucous tissue, and a portion of the alveolar ridge composed of soft flabby tissue only. If an aged patient presenting such a mouth has not long since acquired the knack of wearing artificial dentures, the chances of his success are very unfavorable. The treat-

ment for such a case would be to relieve the pressure upon the whole length of the raphe, let the soft tissue in the vault alone, and increase the pressure upon the soft portion of the alveolar ridge. A vacuum chamber in such a case, placed over a portion of the tense membrane in the highest portion of the vault, would be a source of irritation and useless.

Mucous Membrane.—This membrane must bear the burden of supporting all complete artificial dentures, therefore an appreciation of its capabilities is an important factor to the prosthetist. In examining the mouth prior to taking the impression the condition of health of this tissue over which the base-plate is to be placed should be noted, and if necessary, the required attention given. There are two qualities of this membrane to be considered, tone and tension.

Tone.—This membrane is much influenced by the health of the individual, and may be quite an index of the condition of the general system. The patient will learn that when the general system is vigorous and rested, the denture will have its maximum retention, but when the system is debilitated or relaxed from temporary exhaustion—tired—the retention of the denture will be poor and troublesome. When patients complain that their dentures are not "sticking up" as well as they did, it is well to investigate the tone of the system and explain this principle. When the mucous membrane loses tone for any reason, the retention of the denture will be correspondingly affected. When dissolution is about to take place, it may be noticed that artificial dentures cannot be retained at all. Because of this quality of tone, other conditions being equal, the younger the patient the better the retention. Aged patients in a debilitated state of health and unacquainted with the use of artificial dentures should not be encouraged in having their mouths fitted to new dentures, for the tax upon their vitality may be too great, and hasten their death.

Tension.—When a surface upon which a denture is to be worn is covered with a healthy mucous membrane, evenly underlaid with a medium amount of submucous tissue, and

the tone is good, so far as the tissues are concerned, the very best conditions exist for retaining an artificial denture.

When the soft tissues covering the roof of the mouth are thin and tense, the case is much more difficult. In the former case the tissues will quickly conform to the hard base-plate, and if there has been a reasonably skilful construction of the appliance, the retention will be satisfactory. In the latter case, with the most skilful construction, it will often require an hour or two before the mucous membrane conforms to the unyielding material of the base-plate. It is this class of cases that tempt the dentist to use velum vulcanite lining at the periphery of the base-plate, or to resort to the patent soft vulcanite retainers. As this condition of the mouth is the only logical one in which these retainers are permissible, little harm is done if they are never used where not indicated. In these cases of tense mucous tissue no sharp edges or localized increased pressure by any means whatever can be tolerated. Carving of the cast is contraindicated.

When the mucous membrane is extensively underlaid with soft tissue over the roof of the mouth, and deeply fissured, the case may justly be classed as unfavorable for retention. The cast of such a case may be carved with impunity. The object sought in carving is to cause the periphery of the plate to embed itself more firmly, or to raise a bead just inside of the periphery. This temporarily creates a large vacuum chamber, but as soon as the raised portion becomes embedded in the soft tissues, adhesion by contact is secured. In some cases the bead acts as a barrier to the ingress of an excessive amount of fluid.

Many cases presenting will have areas of thin, tense tissue, and other areas of excessively soft tissue. The treatment for this class of cases has already been stated, that is, relieving of the pressure upon the tense tissue in the proximity of the raphe, to the extent of its entire length. This can usually be accomplished by the addition of one or two layers of No. 60 tinfoil. The soft areas over any portion of the vault should not be changed, but an excessively soft tissue upon the alveolar ridge should be compressed. Rarely

should any hard portion of the alveolar ridge be relieved, and then only when very circumscribed.

Fluids of the Mouth.—The normal thin watery fluid of the mouth is most favorable for retention by adhesion by contact. The fluid makes the contact, but does not hold the base-plate so far away as to interfere with the adhesion by contact. When the fluids are vitiated, thick, and ropy, they may have sticky properties, but not enough to compensate for the interference with adhesion by contact. Temporarily these vitiated secretions can be removed from the mouth by thoroughly washing with an alkaline solution, then inserting the denture well moistened with cold water.

Shape.—The shape of the surface upon which an artificial denture is to rest has much to do with its retention. Side walls are useful to prevent lateral motion; but a flat surface in the vault, or floor of the mouth, is essential for suction. No matter whether the vault is high or low, or the alveolar process of the mandible is high or low, the retentive surface is the horizontal surface presenting. A high inverted V-shaped vault or alveolar process of the mandible is especially unfavorable for suction.

PRACTICAL APPLICATION OF THE PRINCIPLES OF RETENTION

The retention of full dentures may be said to be by four forces: two passive—first, base-plate outline, and second, resistance to force (leverage)—and two active—first, molecular (adhesion by contact), and second, atmospheric pressure

Base-plate Outline.—Much of the burden of the discussion in Chapter I is developing the anatomy of the mouth as a support for and retention of artificial dentures; therefore, the chapter may again be read with this subject, "base-plate outline and retention," uppermost in mind. Figs. 60 and 61 illustrate outlines for a specific upper and lower case. If the impressions are properly taken the landmarks are defined.

Leverage.—Figs. 165 and 166 illustrate the application of force through the teeth upon the base-plate. Where there are two facets, as in the bicuspids, the force may be applied from either facet, then the direction of the force will be at right angle to that surface; but if the force is applied to both surfaces, the direction of the force will be the resultant, and parallel with the long axis of the tooth or teeth. Each specific case should be carefully studied, and these two factors, outline and leverage, should be so controlled that they aid in retention and not in dislodging the artificial dentures. These factors are classed as passive forces, because it is through them that active muscular force may cause

FIG. 165

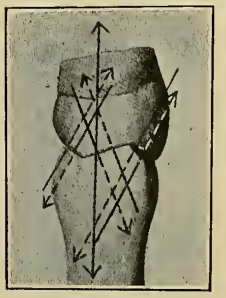


FIG. 166

destructive motion. Fig. 167 illustrates a practical case in which success was not attained until the tilted molar on each side of the mandible was cut down and crowned.

Molecular Attraction, or Adhesion by Contact.—Adhesion by contact is described by the catchy phrase, "uniform pressure and absolute contact," while, in fact, neither statement is true. What is meant is, that the base-plate is so adjusted that it resists force applied at any point within the base plane. In practice this means that the heaviest bearing of the base-plate is at and near the periphery. Absolute contact means that there are no cavities made in the surface of the denture as suction chambers; but it does admit of and requires relief of enclosed hard places. These relief spaces undoubtedly

do cause temporary suction, but this is incidental and not the object. The shape of these relief spaces are usually

Fig. 167

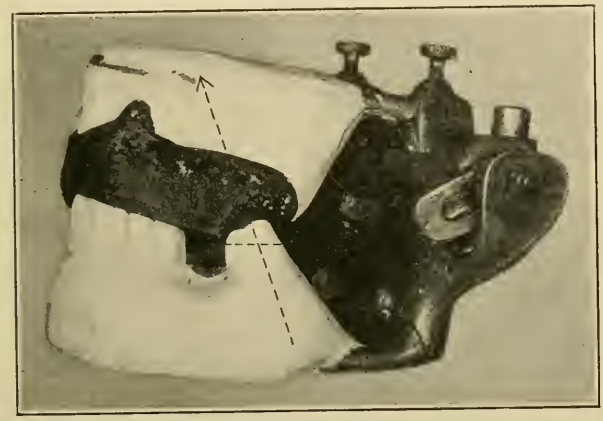
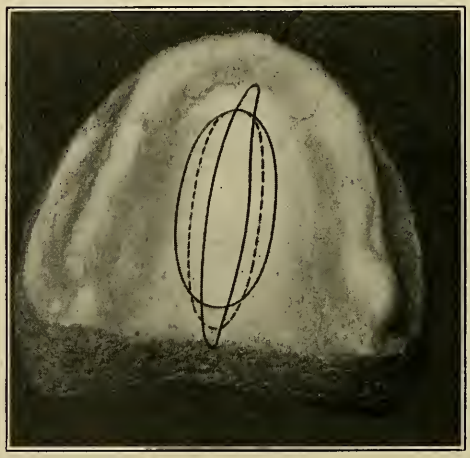


Fig. 168

different from that of vacuum chambers. They conform to the shape of the hard portion to be relieved, while the

vacuum chamber is in miniature the outline of the alveolar process. The most commonly required relief is along the raphe of the maxillæ (Fig. 168). This relief may be made by adding one or more thicknesses of number 60 S. S. W. tinfoil. This foil is $4\frac{1}{2}$ thousandths of an inch thick, hence the desired depth of the relief space may be obtained by additional layers of foil. The relief should be over the whole length of the hard portion, even though it extend from the crest of the alveolus to (and even through) the palatal border

FIG. 169



of the base-plate. Fig. 169 represents three layers of relief tin. The first, the smallest one, is fastened to the plaster cast with sandarac varnish, the second one in size is glued over the first, and the third and largest is fastened in like manner. Any circumscribed hardness, as nodules, wherever located, should be relieved in the same manner as described for the raphe. Another method for relieving the hard places is by compressing the soft places. This should be done by the manner in which the impression is taken which is discussed in Chapter II. In few cases is it advisable to

carve the impression or cast to produce this relief, as the amount removed cannot be correctly gauged, nor the original condition restored if desirable.

Atmospheric Pressure.—Since its application to artificial dentures, in 1840, there has been and is much confusion of thought and expression over the theory and practice with this physical force. The student, after giving consideration to the truths stated in the preceding sections of this chapter, should have no difficulty in formulating a terse statement, for memory purposes, as: Molecular attraction, mass attraction, or adhesion by contact (used as synonymous terms) implies mechanical contact; and atmospheric pressure implies a space with some degree of emptiness.

It is evident that the most advantageous position for a vacuum chamber is about the gravity centre of the denture, which has the least motion, and where the leverage is equal in every direction. The following demonstration and application is from Dr. Burchard in the *American Text-book of Prosthetic Dentistry:*

"The slight movement usual with a plate during mastication tends to separate it from the mucous membrane and permit the access of air to its under surface.

"The line of least movement, as the movement is lateral, a rocking from side to side, is along the median line of the vault; and as the concavity of the hard palate is usually of an irregular vault form, the point of least movement is near its apex. If the movement does not extend to an edge of the chamber, the stability of the plate is not materially affected, but when one of these edges loses its contact, air enters the chamber and adhesion is destroyed.

"The more closely the edges of the chamber approximate this line the less tendency to disturbance there is, so that comparatively narrow chambers are to be preferred; but the depression should be of sufficient size to not materially lessen the effect of a partial vacuum. Naturally the chamber should be in the area of greatest stability, that of least movement. This area will be found around and about the

centre of gravity, and in shape resembling the outlines of the dental arch.

"The dental arch represents, approximately, a parabola in outline. This encloses a trapezoid, the centre of the

Fig. 170

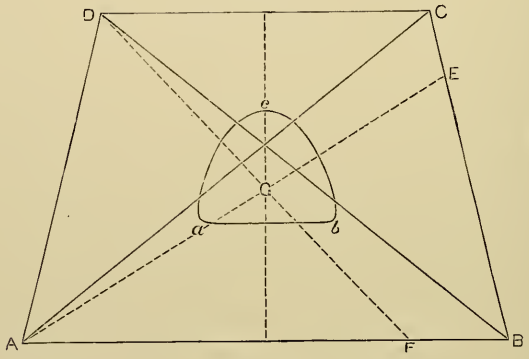
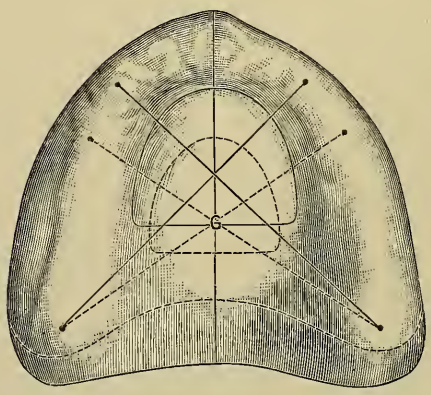


Fig. 171



cuspids marking the extremities of the short, the centres of the third molars those of the long, parallel side. Straight lines joining these points complete the figure. The centre of gravity of a trapezoid is found by suspending it first by one obtuse angle and next by one of the acute angles;

vertical lines dropped from the points of suspension will, in intersecting, mark the centre of gravity. Thus, on the diagram (Fig. 170, *A B C D*) suspend it first from the angle *A D C* and drop a vertical, *D F*. Suspend from the angle *B A D* and drop a vertical, *A E*. Their intersection at the point *G* is the centre of gravity, which is posterior to the intersection of the diagonals." In Fig. 171 application of the principal is applied to the cast.

"About the centre of gravity the vacuum chamber should be placed, its outline following that of the arch, on a smaller scale. In the vast majority of cases the centre of gravity thus determined will be found at about the height of the vault.

"The ends or apex and angles of the chamber should be about equidistant from the centre of gravity—as a rule, the apex of the chamber as far in front of the intersection of the diagonals as the centre of gravity is behind that point.

"To apply these facts practically as a guide to finding the correct position of a chamber, draw first on the plaster cast the median line of the vault. From the centres of the cuspids to the centres of the third molars draw diagonal lines, the diagonals of the trapezoid. When all the teeth are absent, draw the two diagonals from the position formerly occupied by the cuspids to the centres of the tuberosities.

"To find the centre of gravity, draw from the centres of both tuberosities lines to the junction of the first and second bicuspids of the opposite sides other lines, which intersect at a point of the median line *G;* this point will be the centre of gravity of the trapezoid and of the palatal vault. The intersection of the diagonals will mark the focus of the small parabolic area to be covered by the chamber piece. Draw this parabola, its apex about as far in front of the point of intersection of the diagonals as the centre of gravity is behind the latter point, the angle of the parabola the same distance from the centre of gravity as the apex. Should there be a lack of harmony, of bilateral symmetry of the right or left side of the arch outline, make the outlines of the chamber in correspondence."

CONSTRUCTING VACUUM CHAMBERS

Edges.—The edges of relief spaces should be almost imperceptible, while the edges of a vacuum space should be at right angle to the contact surface. The depth of the vacuum cavity should vary from $\frac{1}{64}$ to $\frac{1}{16}$ of an inch. The thinner and tenser the tissue the shallower the chamber, and *vice versa.*

Material.—Block tin or tin alloyed with lead is used to form the vacuum chamber. Pure lead may be used, but it imparts a dark discoloration to the vulcanite. The pattern metal found at the supply houses is tin with a small amount of lead. The material should be purchased in the sheet form and cut for each case. As the metal is supplied in sheet form $\frac{1}{16}$ of an inch thick, a small portion should be rolled to $\frac{1}{32}$ of an inch and the larger portion to $\frac{1}{64}$ of an inch in thickness. All fanciful forms having sharp angles (as heart or shield shape) should be avoided because they are an unnecessary source of irritation.

Attaching.—There are various ways of attaching the chamber forms to the cast, as a thin mix of oxyphosphate of zinc cement (best), sandarac varnish, very small tacks, or a short portion of pins. Fig. 172 shows a cast with a vacuum chamber form attached with pins. When the cast is to be coated with tinfoil the varnish and foil will suffice to hold the chamber form.

For Castings.—The methods described for forming relief spaces and vacuum chambers are suitable for all methods of base-plate formation excepting those by the casting method; for which, owing to the high heat required, these methods cannot be employed. For the casting method the relief spaces and vacuum chamber may be provided for by carving from the impression, or, better, by adding to the surface of the cast a fine-grain investment compound. This addition is made by tracing, with a pointed instrument or sharp-pointed lead pencil, the outline of the desired addition, thoroughly saturating the surface to be added to with water, and painting

on the material as a thin mix. A mixture of two parts, by measure, of wash silica, one part plaster of Paris, and water to make a thin cream is excellent. When the added material is nearly hard set it is carved and burnished into form.

Other Forms of Vacuum Chambers.—The vacuum chamber thus far considered and commonly used is known as the unilateral chamber; that is, it is one and extends equally on both sides of the median line. There are cases in which this form of chamber is not applicable, as cleft palate, deep fissured palate, an inverted V palate, also an overdeveloped raphe. Fig. 173 illustrates an overdeveloped raphe. In

FIG. 172

such cases a bilateral chamber is indicated if any is to be used. A bilateral chamber consists of a complete chamber upon each side of the median line. Fig. 174 is an illustration of a case requiring such treatment.

Soft Vulcanite.—The use of "velum rubber" (soft vulcanite) retainers is a questionable method. It is certainly unsanitary and rarely justifiable. There are two general plans for using velum rubber: (1) As a peripheral border of the vacuum chamber, or the outer edge of the plate; (2) In the form of disks, either as a large central disk, or as small disks distributed about the surface. The rationale of

the first method is to provide a flexible rim that may be readily adapted to a thin tense mucous membrane. In such

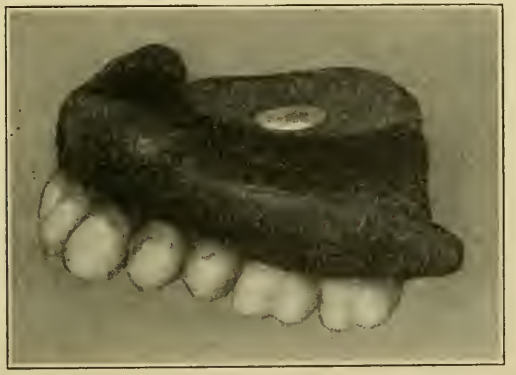
Fig. 173

Fig. 174

cases the method has the stamp of being scientific, but it is unscientific and has the stamp of ignorance to use the method when the tissues are excessively soft and stability

is the result desired. The second method consists of attaching soft vulcanite disks to depressions in the maxillary or mandibular surface of the denture (Fig. 175). The rationale of this method is that the thin pliable disk, by the aid of moisture, easily conforms to a surface covered with thin and tense mucous tissue, then as traction is applied to the denture it draws the centre of the disk away from the tissue, thus forming a vacuum. It is obvious that such a denture is pendently seated, but that it will require much force to remove it from the mouth. The mouths where such methods

FIG. 175



are indicated are rare, and to insert such unsanitary appliances when other methods, properly used, would meet the requirements is reprehensible. As velum rubber contains but two-fifths as much sulphur as hard vulcanizable rubber it is evident that the soft vulcanite is but two-fifths "cured;" therefore, it is easily understood why the material is so much less durable, swells, changes form, acquires an offensive odor, and requires renewal every few months. "Velum rubber" should never be used in the mouth except where the conditions cannot be met by other means, and then it should be renewed often.

Speyer's Cohesion-surface Forms.—Speyer's "Cohesion-surface forms" (cohesion improperly used) is heavy tinfoil, the surface of which is covered with minute papilliform prominences. The claim of strong adhesion due to the peculiar conformation is hardly tenable; however, they are decorative and are satisfying to the mind of some patients; nevertheless, the same thickness of plain tinfoil would produce the same physical results. Fig. 176 shows the material as it is procurable at the supply houses. It should be used only upon the surface requiring relief. A half sheet properly shaped is usually enough for one denture. Fig. 177 is a

FIG. 176

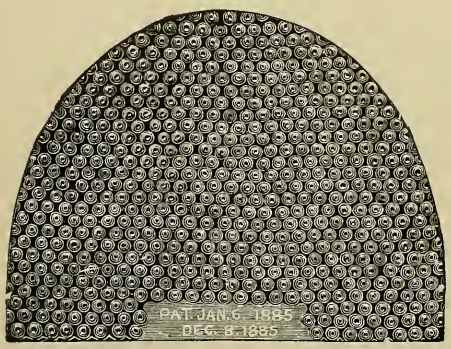
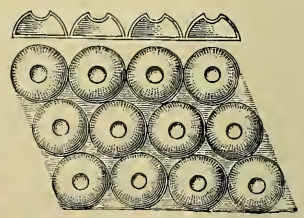


FIG. 177



section of the "cohesion-surface forms" enlarged four times to better show its construction. These "cohesion-surface forms" were used in several of the dentures illustrated in this book. "Contraptions" for retaining artificial dentures, as sometimes seen in supply houses, are not only injurious to the mouth, but often a detriment to retention. The denture is often strongly retained in spite of the appliance. The student should be able, with his knowledge of anatomy and the laws of physics, to detect the unscientific things.

Vacuum Chambers Indicated.—(1) Vacuum chambers are indicated in partial upper dentures when other methods to

be described cannot be used to advantage. (2) Full upper cases where, owing to the fulness of the anterior process, the labial flange of the base-plate is not used. (3) In all full upper cases where the patient is a novice in wearing artificial dentures. (4) Very flat vaults with thin, tense tissues. The shallow chamber ($\frac{1}{64}$ of an inch) is indicated for these cases, unless relief spaces are indicated over the raphe, when it will answer the double purpose of relief and chamber. (5) Flat vaults with an excess of soft tissue, where for any reason peripheral adaptation and compression has not been obtained. These cases will require a deep chamber of $\frac{1}{32}$ to $\frac{1}{16}$ of an inch in thickness.

TENSOFRICTION

This term is used to cover all those methods where retention is obtained by contact, but the surface of the contact is too insignificant to constitute a factor. It includes all forms of clasps, removable plate-bridge attachments, spiral springs, and spring plates. It implies that retention is obtained by friction through tension. The simplest form of tensofriction is the spring clasp, in which the narrow strip of metal grips the tooth by friction through the tension in the metal.

It is not relevant in this book to discuss that class of partial dentures known as "bridge-work;" only to say that there is a large class of cases where the best interests of the patient will be subserved with a plate denture. In all cases the cosmetic effects of a plate is equal to and in many places far superior to a bridge.

It is a good rule to consider that a natural tooth that is or can be made comfortable and useful to the patient is far more valuable than an artificial one. However, the conditions may be such that a remaining tooth or two in the upper maxillæ may be more of a detriment to the wearer of an artificial denture than their loss; but it is always a subject for serious thought.

In a few cases the partial denture may be retained by

atmospheric pressure, adhesion by contact, or by the spring plate; but usually the best results are obtained by the use of clasps.

CLASPS

There is an unjust prejudice in the minds of some dentists against the use of clasps. This is probably due to an improper knowledge of their advantages and disadvantages; also an insufficient knowledge of the mechanical principles involved and their practical application. The advantages of the clasps may be summed up in the statement that there is no method by which a partial plate denture may be retained with so much comfort and usefulness to the patient as with clasps. This implies that the conditions are favorable and the method is properly applied. The disadvantages are that in some cases the method should not be used because the remaining teeth are not healthful nor favorably located and may be of improper conformation. The last condition must preclude clasps. The principal argument used by those who object to the use of clasps is that they cause disintegration of the teeth to which they are attached. The writer emphatically states that the cases in which this is necessarily so are very few indeed; but that most of these unfortunate occurrences are due to imperfect knowledge and manipulation of the dentist. It is awe-inspiring to see how some of these men who throw up their hands in holy horror at the idea of clasping a tooth will, in a few minutes, "disintegrate" a sound tooth to the extent of removing the whole crown and pulp for the purpose of attaching a bridge. Some argue that a tooth should never be clasped until it has been crowned. Why not wait until the necessity arises, and then fill or crown as may be necessary? "Consistency is a jewel." The question should be: How can a patient derive the greatest amount of service from a tooth? not, How can the tooth be preserved the greatest length of time? A tooth is of value only as it is of service.

Names.—There are various forms of clasps. A *stay clasp* is one that rests upon one side and perhaps two angles

of a tooth, and is used as a bearing for a spring plate. A *spring clasp* is one that rests upon at least two sides and three angles of a tooth. *Rigid clasps* are clamping devices that telescope specially constructed artificial crowns. A *ferrule* is a continuous band about the tooth.

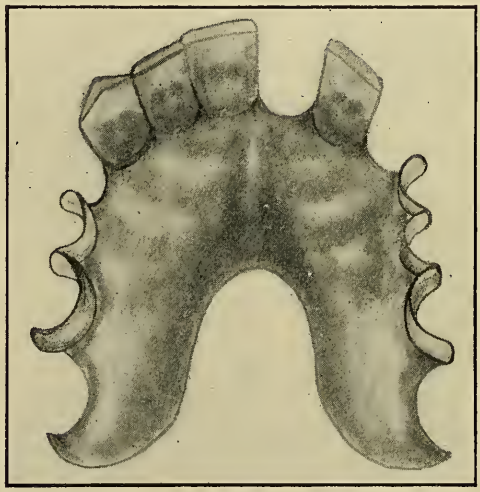
Stay Clasps.—The stay clasp is represented in vulcanite work by the thickened edge of the spring plate. The name is especially applied to the short clasps used to stay mental plates. This means may be used to support a spring plate denture carrying any or all of the six anterior teeth, provided

FIG. 178

the bicuspids and molars are of proper form and alignment. The one essential factor for retaining a denture by the spring plate method is that the distance across the vault from the bicuspids upon one side to the bicuspids upon the other side of the arch shall be greater at the gum margin than at some other portion of the crowns of the teeth. When the remaining teeth have the conformation and alignment implied in the preceding statement, a plate of a "horseshoe" shape, having perfectly adapted thickened edges for vulcanite (Fig. 178), or metal stay clasps (Fig.

179), may be sprung over the bulbous portion of the teeth. It will then rest in contact with the teeth, but without lateral pressure. It can only be removed by springing the heels of the plate inward. Should one or more of the retaining teeth be tilted lingually it will interfere with this method of retention. Perfect adaptation to the cervical third of the lingual surface is essential, and cannot be obtained, or at least retained, if there is an excessive inclining

Fig. 179



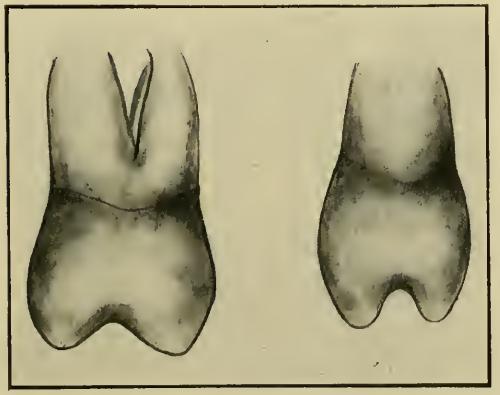
of some of the teeth. There are cases where adaptation can be made to the middle third without contact with the cervical third. This method is especially advisable where the conditions are favorable and there are no spaces for spring clasps, or the spring clasp would be unsightly.

Spring Clasp.—Probably the principal reason for the condemnation, by so many dentists, of the spring clasp is a lack of appreciation of the physical laws underlying their use and construction, and the manipulative ability to

properly adjust them even after the principles involved are comprehended. Doubtless there is no place in dentistry where there is so varied an application of the physical laws of leverage as in the retention of artificial dentures; both full and partial cases.

The Form of Tooth for Spring Clasp.—What is commonly called a bell-shaped tooth is the ideal form (Fig. 180). The greatest diameter of such teeth is from one-half to two-thirds the distance from the gum line, or gingiva, where there is recession of gum tissue, to the occlusal surface of the

Fig. 180

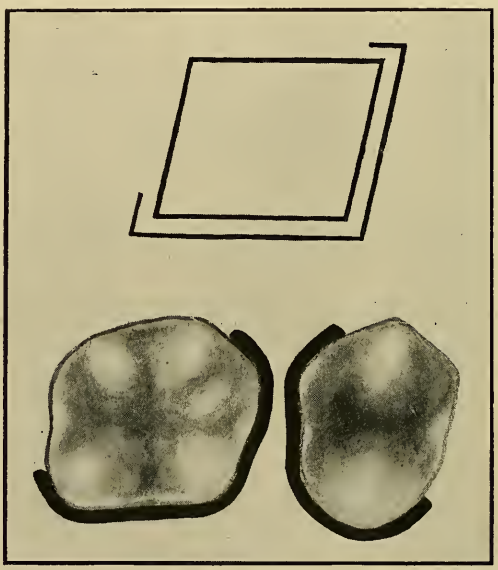


tooth. This being true, it follows that bicuspids and some of the molars only are suitable for clasps; and these must be of more or less pronounced nervous temperament type.

Choice of Teeth for Clasps.—Conditions permitting, the first choice for a tooth to clasp is the second bicuspid, the second choice is the first molar, and the last choice is the first bicuspid. Any other placing of clasps is not ideal, and will be resorted to only because of necessity. Clasps may be placed upon third molars and cuspids, or one of each; but they will be so placed because there is no other alternative.

The Portion of the Circumference of the Tooth Clasped.—The spring clasp should cover two sides and three angles of the tooth (Fig. 181), and be placed upon the distal and lingual surfaces of the bicuspids and the mesial and lingual surfaces of the molars. By this arrangement the clasps are placed at or near the centre of leverage and as inconspicuously as possible.

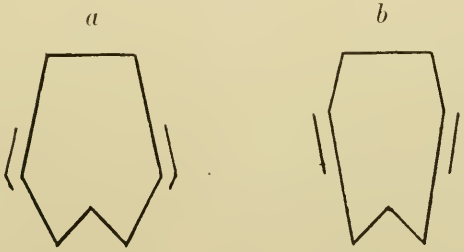
Fig. 181



The Longitudinal Portion of Tooth Clasped.—The pressure must be upon the incline toward the cervix (Fig. 182, *a*). Should the excess of pressure be upon the incline toward the occlusal end of the tooth, the plate will be displaced (Fig. 182, *b*); therefore, the clasp is placed over the middle third of the crown of the tooth. Often the tooth is not an ideal one, and is so formed that it becomes necessary, if a clasp is to be used, to carry it to, or even below, the free

margin of the gum. These are the cases wherein there is danger of disintegration of the clasped tooth. Some teeth thus clasped, that are of a very dense nature and not prone to decay, may become very sensitive, which can usually be overcome by applying silver nitrate, 50 per cent. solution. Should the tooth belong to the class commonly called soft and chalky, and the secretion be in an abnormal condition, they may disintegrate very rapidly; the tooth should then be filled or crowned, as may be indicated. It is not often we have all these untoward conditions; therefore the method should not be condemned because of these exceptional cases. Where the teeth are of suitable length and form, even though

FIG. 182



the structure may be poor and the secretion vitiated, if the clasps are properly made, placed, and cleansed, there will be very little danger of decay. In all cases it is best to keep the clasps as far from the gum as the conditions will permit.

Forms and Material for Clasps.—Clasps are made of either round, flat, or half-round clasp gold. A good formula for clasp gold is: Pure gold, twenty parts; pure copper, two parts; pure silver and platinum, of each, one part.

Round Clasps.—The round clasp should be made of 18- or possibly 20-gauge clasp gold wire, and may be used either as a single or double strand (Fig. 183). The advantage claimed for the wire clasp is the slight contact with the tooth. The disadvantages are: The thickness of the wire will often prevent it being placed between the natural teeth;

it has not the retention power of the flat clasp unless it is placed very near the centre of leverage (this, however, does not apply to the double strand wire clasp); and it is often more unsightly than the flat clasp.

Flat Clasp.—The flat clasp is made of 26-gauge clasp gold, and from $\frac{1}{16}$ to $\frac{1}{4}$ inch in width, usually about $\frac{1}{8}$ to $\frac{3}{16}$ inch (Fig. 184). The advantages of the flat clasp are: (1) Its thinness—when necessary to pass between the natural teeth, the necessary space can be secured by slight wedging; (2) there is no form of clasp that is so universally applicable; (3) it gives great stability to the denture; and (4) it is not liable to be broken. The disadvantage is that the broad

Fig. 183

Fig. 184

surface of tooth substance covered is favorable for decay, and necessitates the best judgment upon the part of the operator in placing the clasp, also care upon the part of the patient to keep it clean.

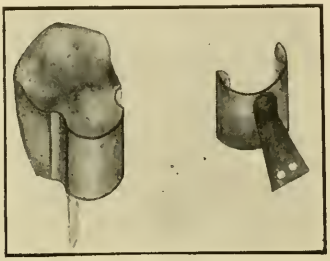
Half-round Clasps.—The half-round clasp is made of half-round clasp gold wire and has the disadvantages of both the round and flat clasps without their advantages.

Rigid Clasps.—These clasps may be made of flat clasp metal or 18-carat gold plate; they are usually as broad as the length of the crown of the tooth will permit; they are of sufficient length to cover at least one side and two angles of the tooth, and the ends are either bent L-shape to slide over parallel longitudinal ridges or cleats upon gold crowns

(Fig. 185) (Bryant method), or they are provided with a thick end adapted to parallel longitudinal grooves in preferably porcelain crowns (Fig. 186) (Swartz method).

Fig. 185

Fig. 186



Ferrules.—Ferrules are especially indicated where the natural teeth are remaining upon one side of the maxillæ or mandible and absent on the other. The ferrule is superior to the spring clasp for this class of cases because of its unyielding form (Fig. 187). Where conditions are favorable, two or possibly three may be used to advantage. Sometimes

Fig. 187

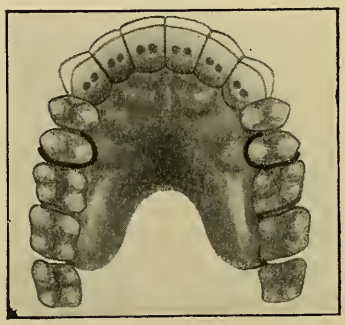
extensions may be attached to the buccal surface of the ferrule to act as clasps upon the proximating teeth. Should there not be sufficient space between the tooth to be ferruled and the proximating teeth to pass a 26-gauge plate, it will be necessary to gain such space by wedging with tape until such space is obtained, when it will be maintained by the ferrule.

PRINCIPLES INVOLVED IN RETENTION

There are two propositions to be considered, first, balancing the plate, and second, gripping the tooth or teeth.

Balancing the Plate.—We may consider each side of a partial plate as a lever, the tooth clasped as the fulcrum, and the plate extending either way from the clasp as the arms of the lever. Fig. 188 represents a partial upper of a horseshoe-shape carrying the six anterior teeth and the wings extending backward to the third molars. It is easily

FIG. 188



imagined what the result would be should an attempt be made to retain this denture by a single strand wire clasp placed upon the third molars; also, should the wire clasps be replaced with broad flat clasps accurately fitted to the surface of the teeth. With the broad clasps, the anterior portion of the plate would be held in place for a time at least, but the long leverage and the weight of the porcelain teeth would place such a strain upon the third molars that they would become very sore and loosened in their sockets. If these clasps are replaced with single strand wire clasps upon the second bicuspids, the plate will be securely held in place and with the minimum strain upon the clasped teeth, because the clasps are at the centre of leverage. This demon-

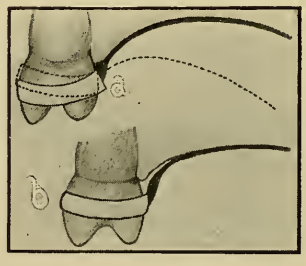
strates why it is necessary to extend the base-plate some distance back of the clasped teeth. This centre also explains why, if a clasp is placed upon a third molar upon one side, a clasp should be placed upon the first bicuspid, or even the cuspid, upon the other side of the arch. It is obvious that the best results are obtained when there is a tooth for clasping upon each side of the mouth. While two teeth for clasping are most desirable, if the conditions for retaining a denture by adhesion by contact are very unfavorable, a single bicuspid or molar may be of much assistance (Fig. 189); and on the mandible even a single cuspid should be utilized.

FIG. 189

Gripping the Tooth.—There are many cases of failure in clasp dentures due to carelessness or slight accidents in adjusting the clasps to the teeth. The clasps should be so adjusted to the teeth that there will be no lateral strain. Theoretically, when the mouth is at rest there should be no strain upon the clasped teeth, because the upper plate (even though a narrow rim) should have sufficient adhesion by contact to sustain its weight, and the lower plate is held in place by gravitation; hence the clasps are a reserve force for work. Fig. 190, *a*, represents a broad flat spring clasp improperly adjusted. The linguocervical edge of the clasp

rests upon the tooth, while the linguo-occlusal edge is somewhat distant from the tooth. When the arms of the clasp are bent inward so as to cause the clasp to grip the tooth, the linguo-occlusal edge will approach the tooth, and the base-plate, which represents the long arm of a lever, will be tilted away from the vault of the mouth, as shown by the dotted line. If the reverse of these conditions exists (Fig. 190, *b*), that is, the linguo-occlusal edge rests upon the tooth and the linguocervical edge stands away from the tooth, then when the spring of the arms draws the clasp firmly to the tooth, the plate will be held securely against the vault of the mouth; there will be, however, a lateral strain upon the tooth, tending to move the apex of the root of the tooth

FIG. 190



toward the vault. If either of these imperfect conditions is to exist, it had better be the latter, because the denture will be held firmly in place, and in time the tooth will be adjusted to the existing conditions; although sore during the orthodontic process.

Adaptation of the Clasps to the Tooth.—There are two methods of adapting clasps: (1) The clasp is formed by pliers to approximately a close adaptation, so that it will be uniformly supported yet not so close but that the fluids of the mouth can pass freely between the metal and tooth. (2) A piece of thin pure gold or platinum (36 gauge) is accurately fitted to the tooth; a strip of clasp metal is then adjusted as closely as possible with pliers to the burnished

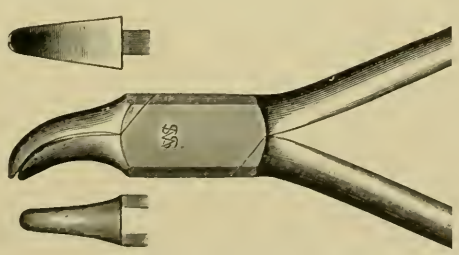
metal and the two united with wax; they are then sprung away from the tooth, invested, and thoroughly soldered together. It is possible, with this perfect adaptation of the clasps to the tooth, the secretions being retained by capillary attraction and not changed by the fluids circulating in the mouth, that disintegration may be invited; but with proper cleansing and removing the denture at night almost no ill effects will present.

Forming the Clasps with Pliers.—Clasp gold is very crystalline, and when it is rolled from the ingot into plate the crystals are elongated into fibers. The metal is easily split between the fibers; across the fibers there is strength and flexibility, so for this reason the fibers should run lengthwise of the clasp, that is, around the tooth. Before forming the clasp the metal should be annealed by heating to a cherry-red heat and permitting to cool slowly.

PLIERS

Two pairs of pliers are required. One (we will call No. 1) with hawk-bill-shaped beaks, the under smaller than the

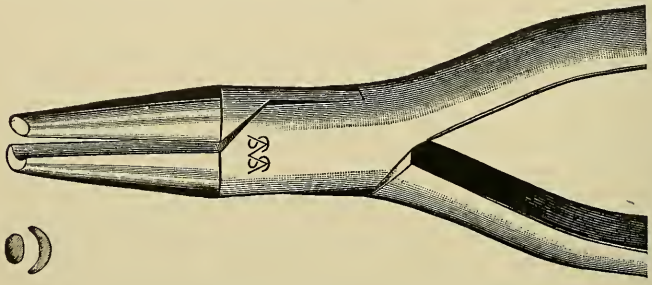
FIG. 191



over beak and oval or round in its cross-section, while the over beak is flat on the under surface of its cross-section (Fig. 191). The other pair of plyers (No 2) is the ordinary

clasp-forming variety, having a round and a concave blade (Fig. 192). No. 1 pliers is for general utility, and with it most of the shaping of the clasps is done. It gives the concavoconvex form to the cross-section of the clasp, and in

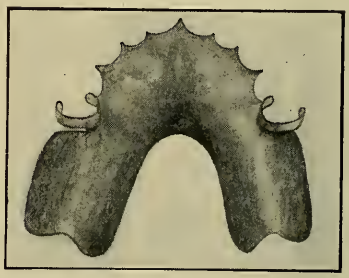
Fig. 192



connection with the fingers give the general outline of the tooth. The No. 2 plyers is better adapted to bending the clasp to sharp angles, depressing a bulging portion or denting the edge of a clasp.

Fig. 193

Fig. 194



Attaching the Clasp to the Plate.—In gold work the clasp is either soldered to the plate (Fig. 194, *a*), or connected to the plate by means of one or two standards (Fig. 193, *a* and *b*). For vulcanite work a tang is soldered to the clasp (Figs. 183 and 184), after which the base-plate may be extended any distance to grip the tang. Fig. 184 *b*, shows union of clasp and tang.

LOCATION OF ATTACHMENT UPON CLASP

The attachment to the clasp should be one-eighth to three-sixteenths of an inch wide, and should be placed as near the middle of the long way of the clasp as the setting of the teeth will permit. By this arrangement a spring clasp will not be converted into an unwieldy stay clasp. Fig. 194, *a*, shows the right way to form the attachments while Fig. 194, *b*, illustrates a wrong way.

Conclusion.—Clasps properly conceived and formed are a blessing to both patient and prosthetist, but improperly used are vexatious to the dentist and a detriment to the victim. The retention of artificial dentures either partial or full is a profound subject for thought, and worthy the best efforts of the prosthetist.

CEMENTATION

This term is used to denote that an adhesive substance, as cement, is used as the means of retention for crowns, bridges, and the so-called "alveolar dentures." Crowns and spanning bridges are clearly out of the scope of this book, while removable bridge-work is on the border line between bridge-work and plate-work. A spanning bridge with one or more saddle abutments is clearly a bridge. A saddle extending under the entire denture is but an extension of the saddle abutment, therefore there is no clear line of demarcation between bridge-work and plate-work. However, a base-plate, of whatever material, depending upon telescoping crowns, bar and slot, tube and split pin, or a pin or ball with slit tube attachments, are so intimately associated with crown work that they will not be further considered in this book.

Except to condemn, the atrocities perpetrated under the alluring name "alveolar dentistry" are unworthy of consideration in any book.

CHAPTER VIII

PORCELAIN TEETH

History.—The late Professor Essig states in the chapter on Porcelain in the *American Text-book of Prosthetic Dentistry* that the history of the first use of mineral in place of animal substances for artificial teeth is wrapped in obscurity. One of the early recorded suggestions along this line is that of Guillemeau, in 1710, who proposed a paste compound of white wax, gum elemi, white mastic, coral, and pearl. Pierre Fauchard, in *Le Chirurgien Dentiste,* 1728, suggests the use of artificial enamel for this purpose.

The idea of "hard mineral teeth" is to be attributed to M. Duchateau, an apothecary of St. Germain-en-Laye, near Paris. He conceived the idea, in 1774, of constructing a plate in porcelain, molding it after the form of his ivory one. M. Duchateau took as an associate a dentist of Paris by the name of M. Dubois de Chemant. M. de Chemant improved the porcelain, and in 1790 obtained a patent from Louis XVI for his process. Dubois Foucou, dentist to the king, became interested in de Chamant's work, made improvements in the material, and made public the first description of the method for making mineral teeth. In 1808, Fonzi, another dentist of Paris, first made separate individual teeth, and also baked small pieces of platinum in them to serve as a means of attachment to the plate.

De Chemant moved to London in 1791 and became associated with Claudius Ash, and for many years experimented in and manufactured porcelain teeth.

Porcelain teeth were not introduced into America until about 1817. The first use of them of which we have knowledge was by A. A. Plantou, a Frenchman, who began the

practice of dentistry in Philadelphia about that time. He commenced the manufacture of mineral teeth about 1820.

Charles W. Peale, in 1822, and Samuel W. Stockton, in 1825, were the next after Plantou to manufacture porcelain teeth, and they were soon followed by many others. By the year 1838 mineral teeth were in general use. About this year Dr. Elias Wildman, of Philadelphia, succeeded in improving the material, so that it would stand the high heat of soldering, and the texture and life-like appearance to such an extent that it has been said that it remains unexcelled to the present day. To him has been accredited the honor of placing the manufacture of porcelain teeth on a scientific basis.

COMPOSITION OF PORCELAIN

Definition.—Porcelain is divided into three classes, as hard, natural soft, and artificial soft. Dental porcelain belongs to the subdivision hard porcelain, and may be defined as: A solidified suspension of one or more unfused silicious substances in a fused silicate. Porcelain is high or low fusing, dependent upon the quality and quantity of the basic ingredient. The material commonly called glass is fused silicious salts; therefore, all porcelains may be converted into glass by sufficient fusing.

Materials.—The materials entering into dental porcelain are feldspar, silica, kaolin or clay, alkalies, and pigments. The pigments used are made of titanium, cobalt, iron, tin, gold, and platinum.

Feldspar.—This is generally spoken of as a double silicate of aluminum and potassium, and is represented by the formula Al_2O, K_2O, $6SiO_2$. The best feldspar is found in the neighborhood of Wilmington, Del. It presents a distinct cleavage, and when broken splits into plates of more or less magnitude. It is of an indefinite color, between yellow and pink, but when fused in the furnace it becomes transparent and colorless, and if not exposed to a too prolonged or an excessively high temperature it retains its original form

without rounding at the corners; this is one of the tests of good feldspar. There are several deposits of this mineral in eastern Pennsylvania, which, though beautiful and transparent in appearance, have been found to be entirely unfit for dental porcelain because of their opaque-white color when fused in the furnace. The preparation of the spar consists of selecting suitable rock (some of the spar from a good quarry will not answer for dental porcelain), breaking it into fragments with a steel and hammer, and grinding it into powder in a Wedgwood mortar. The material is sifted at intervals through a No. 10 bolting-cloth sieve. The grinding should not be carried too far, or its translucency may be greatly lessened.

Silica (SiO_2).—This material, sometimes called quartz, occurs in crystalline and amorphous forms; it is colorless, infusible at ordinary temperature, insoluble in water and all acids except hydrofluoric. The amorphous and gelatinous varieties are partially soluble in alkaline carbonates, but quite soluble in caustic alkalies. Silica combines with the bases to form silicates.

The purest natural form of silica is the transparent and colorless variety of quartz known as rock-crystal. Without transparency and crystalline structure, silica is met with in the form of chalcedony and carnelian, agate, cat's eye, onyx, opal, and other precious stones. Sand, of which the white varieties are pure silica, appear to have been formed by the disintegration of silicious rock. The yellow and brown discoloration is due to the pressure of oxide of iron.

Silica is used for the purpose of giving stability and firmness to porcelain, and its infusibility stiffens and keeps the other materials in shape so that an object made of porcelain may preserve its molded form while exposed to the high temperature during the process of firing. For these reasons it is incorporated with feldspar and clay, and is looked upon as the "main prop in tooth body."

The quartz is crushed and ground in a Wedgwood mortar until it will pass through a No. 10 bolting-cloth sieve, when it is reduced, under water, to an impalpable powder.

Kaolin.—Kaolin is the purest quality of clay freed from such impurities as sand and mica by careful washing. It is a hydrated silicate of alumina, and may be represented by the formula $(2Al_2O_3, 3SiO_2) + H_2O$. It is formed by the long continued action of air and water upon granite and feldspar rock. The disintegration is probably due to both mechanical and chemical causes.

Clay is infusible in an ordinary furnace when heated alone, but readily unites with feldspar at a high temperature. It is an element of strength in porcelain.

German clay is imported from Europe and is probably the most infusible of the clays.

Alkalies.—Both of the alkali metals potassium and sodium are used as fluxing material. Potassium is an essential element of porcelain. Sodium could not be substituted for potassium because of the green tint it imparts to the product; but in conjunction with potassium it is a valuable addition, because it increases the fusibility without increasing the amount of alkali. The potassium and sodium salts are all soluble in water. It is evident that this property in artificial teeth is undesirable, but concomitant with the lowering of the fusing point of the porcelain. Therefore, it is logical to conclude that the higher the fusion of the porcelain the less soluble, and the lower the fusion the more soluble. In other words, the high fusing porcelains are practically insoluble, whereas the low fusing are liable to etch and disintegrate in the fluids of the mouth. Undoubtedly the modern makes of artificial teeth are sufficiently high fusing to be insoluble in the mouth; but the porcelains placed upon the market for the dentist's use in constructing bridges, crowns, and inlays, excepting the highest fusing ones, are dangerously near the etching point. Material has been placed upon the market so loaded with flux (alkali) that they soon prove to be unstable. In using low fusing porcelain, to be placed in the mouth, this property of solubility (etching) must be taken into account; as low fusion can only be produced by adding flux (however, excessive pulverizing lowers the fusing point, also injures the texture), and the more flux the more soluble.

It is interesting to study the four essential elements entering into porcelain—oxygen, silicon, potassium, and aluminum; one gas and three solids; two non-metals and two metals. Of the three solids, silicon melts at 1500° F., potassium at 144.5° F., and aluminum at 1200° F. Oxygen is the most abundant and silicon second most abundant element, while aluminum is the most abundant metal. Silicon combined with oxygen (silica) is almost infusible and insoluble, and there is almost no expansion or contraction by heat. Aluminum combined with oxygen (alumina) is highly refractory and non-changeable. Potassium combined with oxygen forms potassa; it fuses at a low temperature, and is very soluble in water. Silica combined with alumina forms kaolin (clay), is refractory, easily hydrated, and contracts in heating. Silica and alumina combined with potassa forms feldspar, which material forms the largest portion of artificial teeth.

Pigment.—The pigmentary substances, titanium, cobalt, iron, and tin, are used in the form of oxide; gold is used both as an oxide and in the metallic state; and platinum as a fine precipitate-platinum sponge.

Titanium oxide is the only pigment used in the "body porcelain." It gives the creamy yellow color of the dentine. It is also used for the yellow color of enamel.

Cobalt oxide produces the blue tints of enamel.

Iron oxide is used for certain gray tints.

Tin oxide is used only in combination with gold oxide as purple of Cassius to produce the pink gum color.

Gold is used in the metallic state for reddish-brown tints in enamels.

Platinum sponge produces gray tints.

THE PROCESS OF MANUFACTURE

The process of manufacturing artificial teeth consists of (1) preparing the stock material, (2) molding, and (3) firing.

Stock Material.—The stock material is first worked up into three forms, as body, frit, and enamel.

Body.—The body represents the dentine of the natural teeth. It is the highest fusing portion of the porcelain. It is composed of feldspar, silica, kaolin, and titanium oxide, with a small amount of starch to make the material plastic for molding.

Each manufacturer has his secret formulæ, but the following formula gives an idea of the proportions of the ingredients: Kaolin, 1 ounce; silica, 3 ounces; feldspar, 18 ounces; titanium oxide, 65 grains; starch, 10 grains to each ounce.

Frits.—The frits are the colors prepared for the enamels. They consist of the pigment substance mixed with feldspar and flux ground exceedingly fine, fused into a glass and reground for use. A typical formula would be: Platinum sponge, 1 pennyweight; feldspar, 1 ounce; flux, 20 grains.

Enamels.—Enamels are composed of feldspar to which has been added a sufficient quantity of frit and flux. A typical formula for enamel is: Feldspar, 1 ounce; gold frit, 6 grains; platinum frit, 4 grains; flux, 20 grains.

Flux.—Used to lower the fusing point of enamels and porcelains. A good formula is: Silica, 12 ounces; glass of borax (sodium borate), 3 ounces; potassium carbonate, 3 ounces.

Molding.—Artificial teeth are made in brass molds. As porcelain shrinks in firing, the desired tooth is first carved in plaster in enlarged form. From these enlarged forms brass molds are produced. Figs. 195, 196, 197, and 198 illustrate the molds used for two sets of fourteen upper teeth. The molds are made double for convenience in keying the parts together.

The brass molds are oiled and the platinum pins placed in the little holes on the pin side of the molds. The point enamel is then put in the face side of the mold and arranged with a small spatula to the full thickness at the point and tapered down sparingly toward the neck. A thin coat of point enamel is placed on the lingual side of the front teeth and on the masticating surfaces of the bicuspids and molars. Some makers of teeth use but one enamel; instead of apply-

ing a yellow-neck enamel, they allow the body to show at the neck of the tooth; this is probably done to save time and labor, but it does not afford the best results as to translucency and natural appearance.

Fig. 195

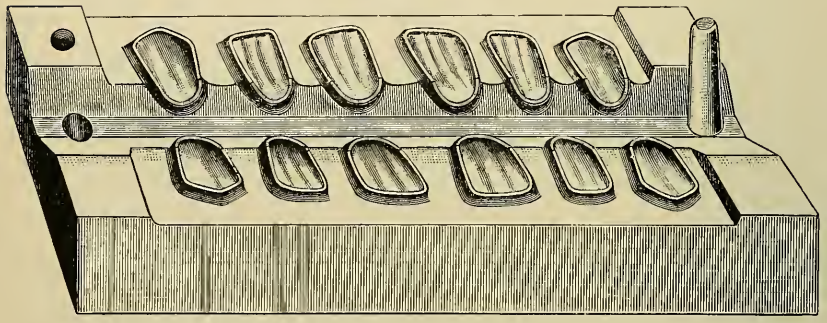
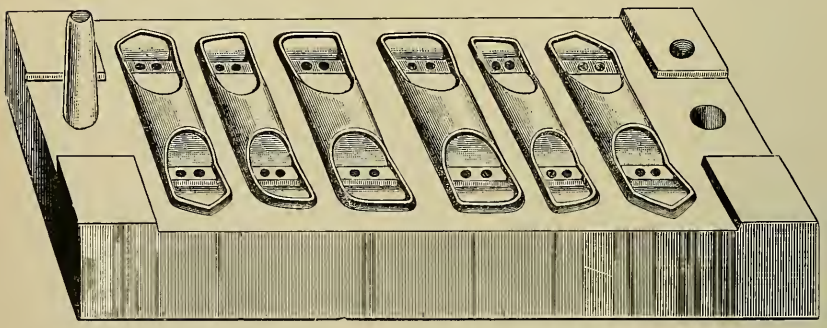


Fig. 196



The body is applied in small pieces slightly in excess of the quantity needed for each tooth. These are picked up with a small spatula, formed into balls, and laid on the pins in the pin side of the mold. The two sides of the mold are then placed together and heavily pressed. The mold is then removed from the press, put in an iron clamp, and secured firmly together; it is then heated on a stove until the mold

becomes hissing hot, after which it is removed and allowed to cool sufficiently to handle. The mold is then opened and the teeth dislodged and removed by striking the mold with

FIG. 197

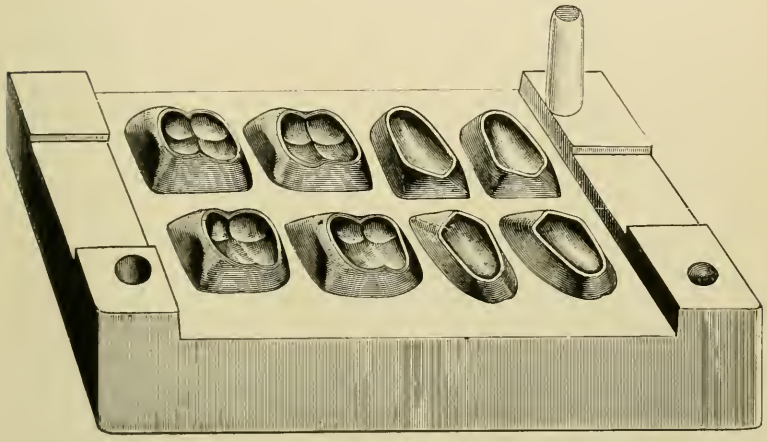
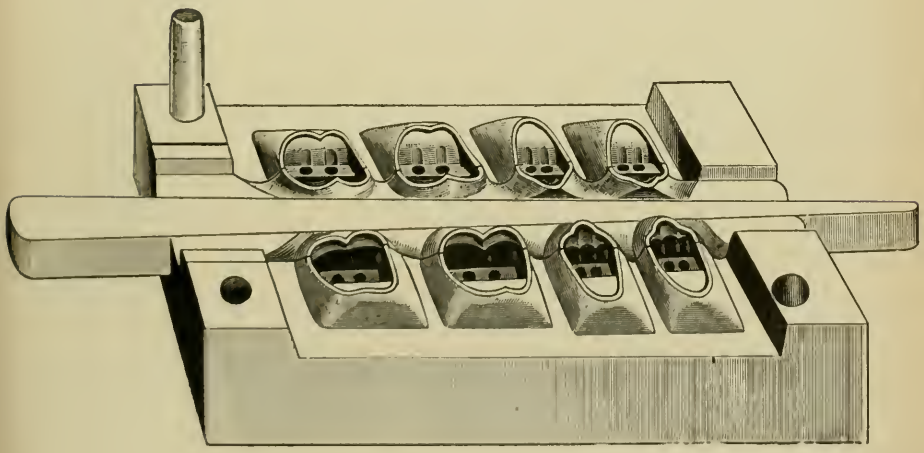


FIG. 198



a wooden mallet. If the heating has been carried to the proper point, the teeth will be hard enough, through the agency of the starch in the formula, to admit of trimming. This is done with fine files.

Burning.—In manufacturing on a large scale the blocks are arranged in complete sets on a fire-clay slide covered with coarse quartz. These slides are $6\frac{1}{2}$ inches in width by $9\frac{1}{2}$ inches long; they have raised edges to retain the quartz, which serves as a bed for the teeth.

The furnaces used by the large manufacturers have a capacity of three or four hundred sets per day for each furnace. The furnace has a heating oven over the muffle. The muffle is constructed of the best fire-clay, 27 inches long, 8 inches wide, $5\frac{3}{4}$ inches high, and $1\frac{1}{4}$ inches thick. The muffle must be thoroughly swabbed with clay, mixed thin with water, to fill up all cracks or defects through which the gases from the fuel might enter the muffle. Such accidents are of frequent occurrence in burning, and are always ruinous to the teeth, the gas generally imparting to them a ghastly blue appearance. The furnace has a flue at the top connected with a smoke stack, and is heated with oil.

The slide containing the teeth is placed in the heating oven at the top of the furnace before burning; this preliminary heating prepares them for the higher temperature of the muffle. The length of time required for burning the teeth varies with the heat of the muffle. About fifteen minutes is usually required. A too rapid heat tends to burn out or vaporize the color of the enamels. The proper glazing of the teeth is ascertained by placing under a gas jet. When the burning is satisfactorily accomplished they are put in the cooling muffle, protected from air drafts, and left undisturbed until quite cold.

CLASSIFICATION OF PORCELAIN TEETH

Porcelain teeth may be divided into two general classes, namely, plain and gum teeth. In the former the crown of the tooth, and sometimes a portion of the root, is represented,

whereas, in the latter class the labial and buccal gum is added to the crown. The base upon which they are to be mounted and the means of attachment to the base further divides them into classes as follows:

Plain Teeth
- Vulcanite teeth (Fig. 199).
- Countersunk pin teeth (Fig. 200).
- Pinless or diatoric teeth (Fig. 201).
- Plate teeth (metal work) (Figs. 202, 203, 204).
- Continuous gum teeth (Fig. 205).

Gum Teeth
- Gum section teeth (for vulcanite) (Figs. 210 to 215).
- Single gum teeth (for metal work) (Figs. 216 and 217).

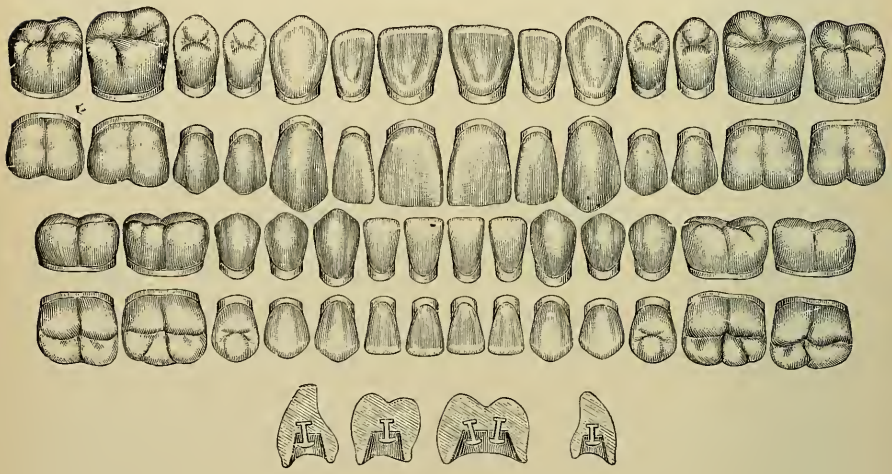
Attaching Teeth to Base.—The means by which the porcelain teeth are attached to the base-plate upon which they are mounted is usually two platinum pins, the headed ends of which are embedded in the substance of the teeth and firmly fixed in it when the porcelain is baked. Platinum and porcelain have very nearly the same coefficient of expan-

FIG. 199

sion, so that in a similar range of temperature they approximately expand and contract alike, and there is small danger of a cracking of the tooth or a loosening of the pin. It must be remembered, however, that the capacity for absorbing heat differs greatly with the two substances, platinum having a much higher specific heat, which fact, coupled with its

greater conductivity, makes it necessary that a greater amount of heat should be applied to the porcelain when teeth are subjected to high heat. The platinum does not fuse at the high temperature necessary to the baking of the body of the tooth, and its non-oxidizable surface makes it possible for the porcelain to adhere to it with considerable tenacity. One manufacturer alloys iridium in small amount with the platinum to give the pins greater rigidity and tensile strength.

FIG. 200



The great cost of platinum has been responsible for many attempts either to substitute other and less expensive metals for it, or to reduce the amount of metal used for the attachment in the tooth, or to dispense with the pins altogether. The less expensive metal usually employed is nickel or some of its alloys, but as these readily oxidize during the baking, the intimacy of the union between pin and tooth cannot be so close as where platinum is used. The discoloration of the tooth from the dissolved oxides of the pins is frequently sufficient in amount to be objectionable, and the low fusing

body which is necessary with teeth of this sort is not so strong as that which may be baked on platinum pins. The attachment of pins of base metal to platinum anchorage baked in the tooth by soldering the pin to the anchorage is an ingenious method adopted by one manufacturer to reduce the amount

FIG. 201

FIG. 202

FIG. 203

FIG. 204

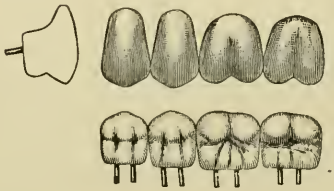


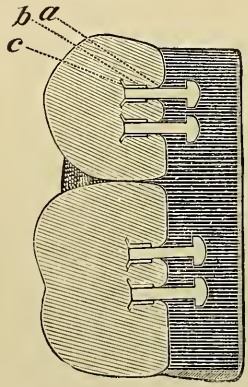
FIG. 205

of platinum (Fig. 206). The anchorage is in the form of a tube embedded in the porcelain, the inner end of which is expanded into a flange which is for firm retention. The pins of alloy are made to fit the tubes and are soldered to them with high-grade solder, and tests seem to have proved that the teeth are strong enough for satisfactory service.

The construction of teeth whose attachment is by means of an undercut recess in the tooth filled with the plastic base

upon which they are mounted is another attempt to reduce the cost of production by doing away with the platinum entirely. They are called "pinless" or "diatoric teeth." The mechanical difficulties in the construction of a tooth of this type, which shall be sufficiently strong, have limited

FIG. 206



a, base metal pin; *b*, platinum anchorage; *c*, expanded end of same.

their use practically to the bicuspids and molars, in which positions under favorable conditions they are eminently satisfactory. It must be remembered that as their strength depends upon the bulk of porcelain composing them, and that as this is less than in pin teeth, it is not possible to make more than minor changes in them by grinding.

Forms.—The forms of porcelain teeth are determined by three factors. The most important of these is the anatomical characteristics of the teeth they are to substitute. As only the crown is represented, the labial or buccal surfaces, the morsal surfaces, and such portions of the approximal surfaces as are presented to view, are patterned after the natural teeth. Teeth quite satisfactory in this respect are manufactured today, although the market contains many made according to old designs which are poor imitations of the natural organs. The form of the incisors and cuspids is in

general much better than that of the molars and bicuspids, the occlusal surfaces of many of which are too narrow for the best masticatory results, the cusps are too poorly defined, and no attempt is made to have those of opposing sets fit together.

The shape of the other portions of the teeth is determined by considerations relative to their attachment to the base upon which they are mounted, and by the mechanical requirements which the shape and relation of the jaws impose. Teeth for rubber and celluloid work are similar in design. When the latter came into use the artistic pos-

FIG. 207

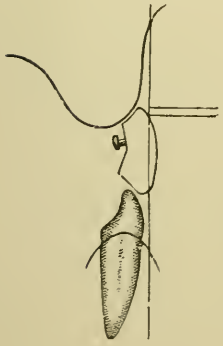


FIG. 208

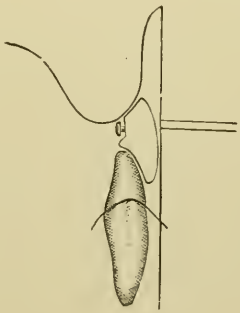
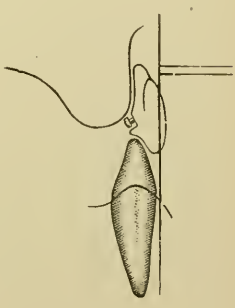


FIG. 209



sibilities of the new material created a demand for more natural forms in teeth, and so-called "celluloid" teeth were designed to meet it. Teeth of this form may also be used with a cast metal base, but they are all designated rubber teeth.

Plain rubber teeth are provided with two-headed pins to secure their attachment to the vulcanite. In the incisors and cuspids there is the so-called "pin guard" situated between the pins and the morsal edge to afford a shoulder to which the vulcanite may be finished. The "ridge lap" (Figs. 207, 208, and 209) is that portion of the tooth which comes into relation with the alveolar ridge, and may be long or short

in accordance with the requirement of the case. The "bite," or "overbite" as applied to incisors and cuspids is that portion of the tooth intervening between the pin guard and the morsal edge. The "shut of the jaws" refers to the distance between the jaws when the mandible is in the proper position for the occlusion of the artificial teeth. Thus, where the distance is marked we have a "long shut," which demands the use of a tooth that will fill in the space, and hence is known as a long-shut tooth. A long-bite tooth would fill in the space, but it would throw too much strain upon the pins to remove them so far from the point of stress. The bite, shut, and ridge lap, it will be seen, are all correlated.

Countersunk pin teeth were introduced about 1885. Their lingual surface corresponds in shape to that of the natural teeth, the attachment to the molded base being by means of pins located in a depression in their base. Their close conformity in contour to the natural organs makes them more acceptable to the tongue than teeth backed in the ordinary way, and renders articulation easier and more distinct.

Inasmuch as they must be mounted almost over the alveolar ridge, they cannot be used in cases with a short bite.

For a vulcanite base the case should be flasked in the usual way, but in packing each countersink should be carefully filled with small pieces of rubber to insure the rubber being thoroughly forced into the countersink and around the pins.

Plain plate teeth are designed for use on a metal plate or in crown-and-bridge work. The incisors and cuspids, in either instance, are similar in form, but those for use in the bicuspid and molar region for crown-and-bridge work represent only the buccal surface of the tooth, and are sometimes known as "veneers."

Continuous-gum teeth are illustrated in Fig. 205. It will be seen that they have only one long pin, and that the buccal and labial portions of their roots are represented in porcelain. This contributes to the firmness of their attachment to the base, the porcelain body fusing upon the roots

and uniting them to the plate. It also maintains the contours of these regions by reducing the amount of porcelain body to be baked, and hence the contraction in this locality.

Gum Teeth.—Gum teeth are made for metal plates and for the plastic bases, those for the former being at this time made only as single teeth, while those for the latter are usually in sections of two or more teeth and designated

Fig. 210

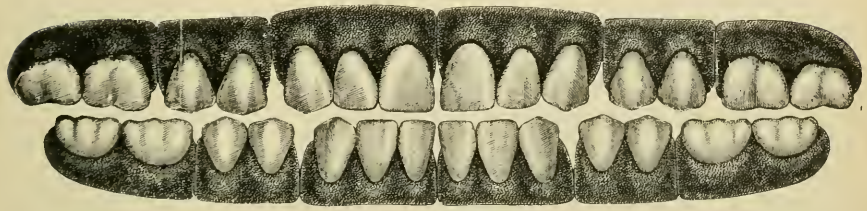


Fig. 211

Fig. 212

Fig. 213

Fig. 214

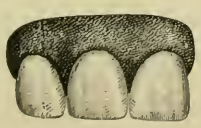


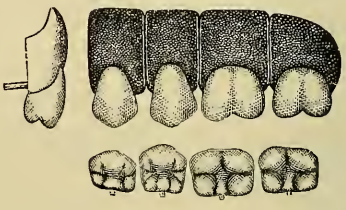
Fig. 215

"gum section" or "block" teeth (Figs. 210 to 215). The use of gum teeth is limited to those cases in which resorption of the alveolar process has taken place to such an extent as to demand considerable restoration by means of the denture. With the exception of that found in continuous-gum dentures the porcelain of gum teeth provides the best imitation of the natural tissues that has been obtained, but the fixedness of

the relation between the teeth in the section, and the difficulty of joining, particularly of the single gum teeth, are drawbacks which this does not overbalance. The artistic possibilities in arrangement which plain teeth offer have

Fig. 216

Fig. 217



caused them to come into general use, and in most cases they are to be preferred. It must be remembered, however, that in some full dentures, and many partial ones, gum teeth may be used to great advantage. They are made in a variety of forms and offer a wide selection.

IMPROVEMENTS IN TOOTH FORMS

In 1907 Dr. J. Leon Williams, of London, England, started a campaign in the dental journals for better tooth forms. The results are being seen, as some of the manufacturers are placing upon the market improved forms of bicuspids and molars.

Dr. Williams found it was no easy matter to induce the manufacturers, with their expensive equipment of molds and large stock of artificial teeth, to abandon their established methods, though unsatisfactory, and adopt a new system based upon an untried theory. However, being a man of a highly cultivated artistic temperament and much determination, he resolved that the time was ripe for the much needed improvements in artificial teeth, and that it should be brought about.

His scheme contemplates the standardizing of the necessary stock of artificial teeth. (1) By selecting the typal forms in as small a number as possible to meet all require-

ments. This he finds by study can be accomplished with twelve typal forms and three sizes of each form, making thirty-six molds. (2) The artificial teeth to be accurate reproductions in size and form of natural teeth representative of the typal form. These teeth to represent the slightly worn condition of well-preserved teeth of middle-aged people. (3) That each of the classes of teeth, as vulcanite, metal plate, crown and bridge facing, and crowns shall be duplicated in each of the forms and sizes. (4) That sample cases shall be equipped with blank (without pins) teeth of the twelve medium-sized molds. Thus, the practitioner with his twelve sets of blank teeth will have a guide to every tooth the system contemplates. Necessarily considerable time will be required to carve the model teeth, make the molds, and manufacture the teeth to stock the market. However, they are promised for the near future.

BASE METAL PINS

On another page mention has been made of the use of base metal as a substitute for platinum in the pins of artificial teeth. This is regretable because it has cheapened the product far beyond the financial saving. In fact, it is questionable if the saving in production justifies the difference in the selling price; if it is not largely sophistry for selling the product. If such debased material is to be used in the mouth, it can logically be used only with cheap work. The dentist should feel that to use inferior stock in high-grade or high-priced work is an imposition. The blame can only in small part be placed upon the manufacturer, because he is consistently in the field to meet the wants of the profession; although his enthusiasm for trade may warp his judgment and color his statements. The blame is largely to the discredit of the dentist, because his only motive can be no more than the saving of a few pennies on a set of teeth, for which he risks his reputation and brings reproach upon his profession. The profession should demand of the dental trade the best only that science and art can produce. The lowering of the standard of quality should in no wise be encouraged.

CHAPTER IX

DOUBLE VULCANIZATION METHOD

In the preceding chapters the underlying principles, the nature and the requirements for artificial dentures has been discussed. Chapter VI treats of the history, appliances, and primitive method of vulcanite construction, while this chapter presents an advanced technique of construction. By double vulcanization is meant that a vulcanite base-plate is made, and to it the superstructure is added at a second vulcanization. The advantages of this method over the single vulcanization method is that it provides a perfect fitting base-plate, provided the impression was a good one; and it very much facilitates the developing of the esthetics or cosmetic effects of the artificial denture.

TECHNIQUE

The method consists of taking the impression, making the cast, forming the base-plate, obtaining the occlusion and contour models, arranging the teeth, and proving the contour and expression; of preparing the case for flasking, packing, vulcanizing, and finishing.

Impressions.—It is imperative in this as in all kinds of artificial dentures that a perfect plaster impression be obtained. The technique of this operation is described in Chapter II.

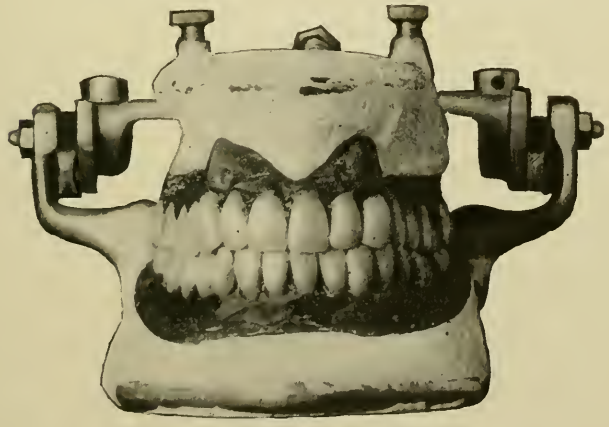
Cast.—Because of the heavy pressure to which the cast will be subjected in molding the rubber, it should be made of a material that cannot be easily compressed. Spence plaster compound is best for this purpose (see Chapter III). Additions are made to the cast either in the form of a relief or as a vacuum chamber (see Chapter VII).

Base-plate.—The vulcanite base-plate is constructed as described on page 132. The base-plate should be constructed of the purest rubber, as Dougherty's pure black rubber, Traun's uncolored rubber, or Ash's dark elastic rubber.

Occlusion and Contour Models.—The occlusion and contour models are constructed as described on page 133. The models are mounted on the New Century Antagonizor by aid of the Snow face bow (Fig. 98).

Mounting the Teeth.—The teeth are mounted as directed in Chapter VI (Fig. 218). The patient is about sixty years of age and of the sanguine modified by the nervous temper-

FIG. 218

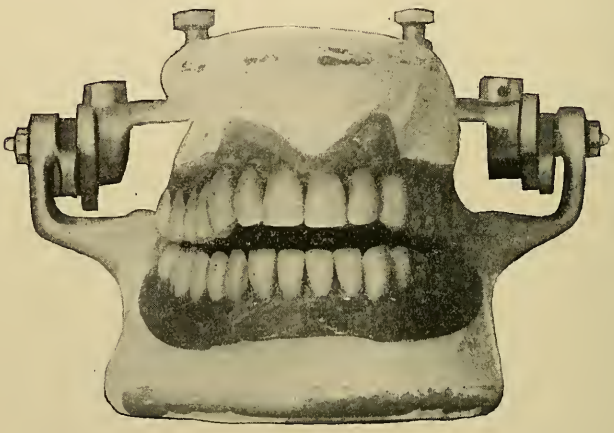


ament. The teeth selected for the case were S. S. W. "natural forms," mold No. 227, Shade No. 40. It will be observed that the teeth are of sufficient length to nearly fill the space between the high and low lip lines, so that when the lips are parted to their farthest, only a slight trace of gum restoration will be observable—so slight, indeed that the material should not be noticeable.

The overlap may be seen in Fig. 218. The lateral incli-

nation, compensating curve, and diverging straight line are shown in Fig. 219. The esthetic features may be studied in Figs. 218 and 219.

Fig. 219

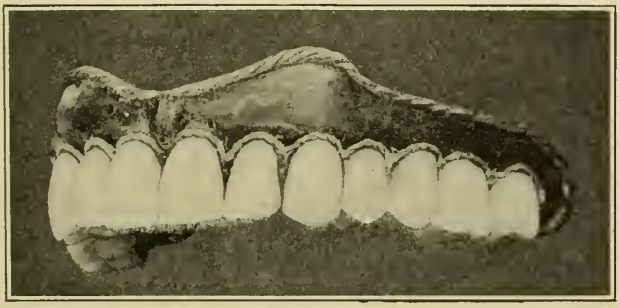


Proving the Contour and Expression.—This phase of the subject is discussed in Chapter XVI.

Preparation of the Case for Flasking.—Strings are used for outlining the festoons and periphery of the gum. The object of the festooning string at the cervical portion of the teeth is to give the proper thickness to the margin of the gum. The string used for this purpose is waxed dental floss, twisted very hard, doubled, and twisted again. In doubling, the loop will show the direction it should be twisted the second time. Wax the string well with softened wax and apply it by grasping the left heel of the plate between the fingers and thumb of the left hand, with the occlusal surface of the teeth upward; place one end of the string at the distal surface of the second molar, pressing it gently into the wax; outline the margin of the gum, using the wax spatula to carry the string well into the interproximal spaces. The peripheral string should be well-waxed wrapping twine, placed at the outer edge of the wax, and secured in place

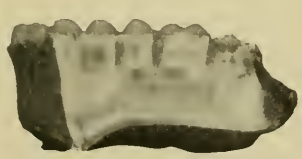
by melted wax made smooth with a hot spatula. Fig. 220 illustrates the usual manner of applying the strings. The peripheral string should be applied at the line of separation of the flask, and this must be, in cases of heavy restorations, at the widest portion of the wax model.

Fig. 220



The next step is to cover the buccal and labial surfaces with a strip of No. 60 tinfoil. Instructions are necessary in applying the tin over the strings. The No. 3 instrument of the Evans set of carvers (Fig. 104) is especially adapted for adjusting the tinfoil. The strip of foil is placed over the

Fig. 221

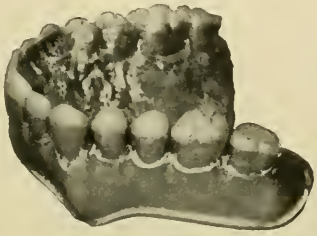


wax and teeth and pressed as closely as possible with the fingers. The surplus tin is cut away with fine-pointed scissors. Two pairs are desirable, one straight and the other curved. The edge of the tin may be anywhere between the morsal ends and the middle of the teeth. The tin should be slit between each two teeth. Fig. 221 shows the tin

trimmed and slitted. Hold the work in the left hand, seize the instrument by the hand grasp, rest the thumb upon the occlusal surface of the second molar, and burnish the tin closely to the tooth and against the festoon string. Continue this operation with all the teeth. After adjusting the tin about the teeth, the metal must be burnished over the string to give the desired thickness of the gum and the contour of the festoon. This is done by holding the plate and burnisher in the same manner as before. The instrument must extend one-sixteenth of an inch beyond the string and at the same time must rest upon the body of the tooth while pressing the tin down over the festoon string. By this means a proper thickness and contour is given the margin of the gum, without forming an unnatural beaded edge. After all the teeth have been thus treated, the position of the plate should be reversed in the left hand, so that the thumb of the right hand may rest upon the periphery of the base-plate while burnishing the tin from the festoons toward the periphery. With a pair of sharp curved scissors trim the tin flush with the peripheral string, but do not permit it to overlap the vulcanite base-plate. The case is now ready for tinning the lingual surface. Use No. 60 foil, and if the vault is a high one, slit the tin from the middle of one side to the centre. Place the inner end of the slit over the middle of the vault, and one edge of the slit along the raphe to the palatal border; press the side of the foil gently against the wax and teeth; press the other half of the tin, in the same manner, into position, permitting the slit portion to overlap the first half. With sharp scissors trim the tin nearly down to the teeth. Remove the foil and place it upon a plaster or metal cast having well-defined rugæ, and burnish the rugæ into the foil. Remove the foil, turn it over, and fill the impressions of the rugæ with wax, also smear the remainder of this surface with a thin layer of wax; now replace the waxed surface against the vault of the plate and nicely adjust with the fingers. The tin must be securely burnished against the teeth. The lingual contour of the teeth is produced by roughly carving away the excess

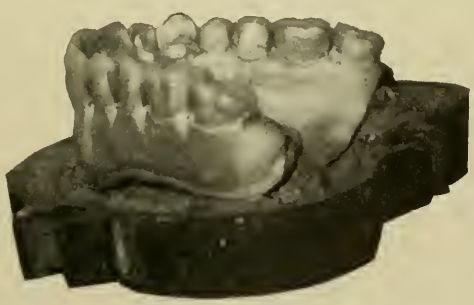
of wax, with the Evans wax carvers, just before placing the tin. The tin is also slit between the teeth on their lingual aspect and nicely burnished to place (Fig. 222).

Fig. 222



Flasking.—A flask with a narrow rim is imperative. The star flask, as shown in the following illustrations, will do very well, but one made by the Cleveland Dental Manufacturing Co., called the Wilson flask (Fig. 108), will better serve the purpose. This flask is designed to be used with the Donham clamp (Fig. 109).

Fig. 223



The maxillary surface of the case, having been cleaned of wax, is filled with Spence's compound, which forms a cast upon which the denture is vulcanized. This vulcanization cast should be not less than one-fourth of an inch thick at

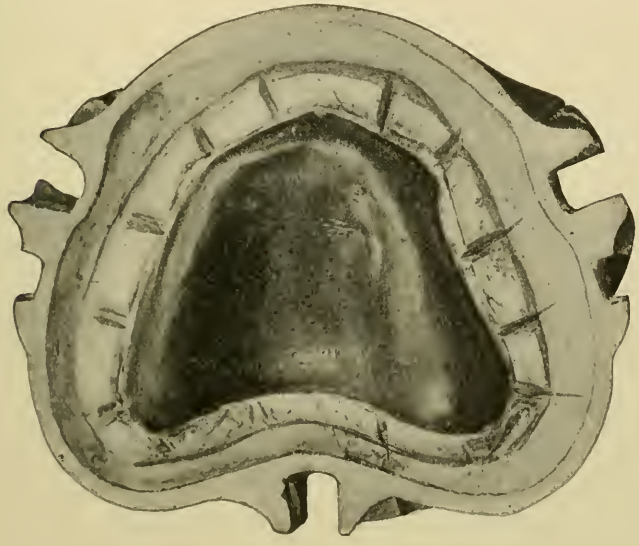
the thinnest portion of the vault, and should not overlap the tin facing. In one hour this cast will be sufficiently hard to place in the first section of the flask with regular dental plaster (Fig. 223). The peripheral string will be a great aid in outlining the denture in the flasking plaster. After the plaster has set, it is coated with a separating fluid, and then held under the faucet so as to moisten the tinfoil and thus facilitate the flowing of plaster into the interproximal spaces at the time the flasking is completed. The flask should stand about thirty minutes and then be placed over the stove in a stew-pan of cold water, to be heated up as before described on page 251.

Fig. 224

Separating the Flask.—When the heat of the water indicates the time for opening, the flask is grasped with a cloth holder in the left hand and separated by the point of a knife-blade or wax spatula inserted at the heel of the flask. The instrument should be guarded by the thumb and finger of the right hand to avoid the possibility of marring the case.

The strings and as much of the wax as possible are removed with the spatula, after which the remainder is removed by pouring boiling water upon it; then with a cloth the tin lining and vulcanite base-plate are wiped dry (Figs. 224 and 225). The excess space is cut with small gate connections (Fig. 225), and the separated flask is placed over the sheet-iron to warm as previously described (Chapter VI, Fig 156).

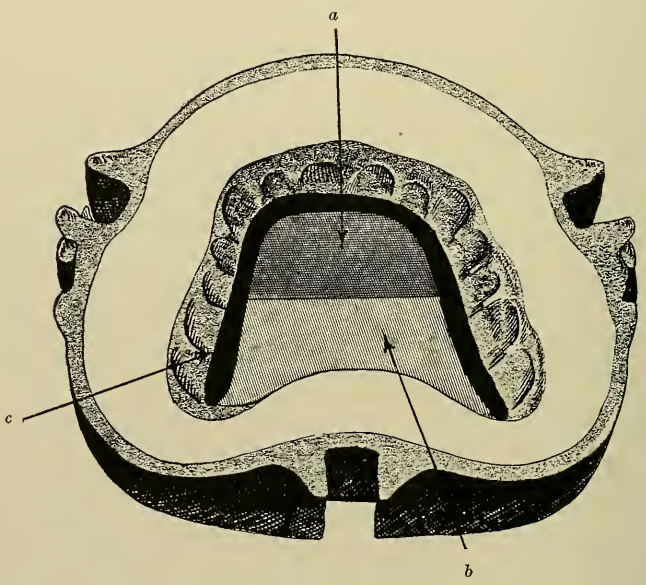
Fig. 225



Packing.—Sufficient Gilbert Walker's granular gum or pink rubber is cut into strips to form a layer of one thickness over the tinned surface. First pack a narrow strip of red rubber about the pins (Fig. 226, *c*), and small square or triangular pieces of granular gum between the cervical portions of the teeth. The strips of granular gum are then placed over the labial and buccal surfaces of the matrix with the fingers and wax spatula so that no space remains through which the red rubber can escape. The strip of red

rubber about the pins should be pressed down with a wax spatula to form a symmetrical outline. A piece forming a half-circle of granular gum is then placed over the anterior portion of the lingual surface (Fig. 226, *a*), and with the wax spatula the circular edge is joined to the red rubber about the pins of the teeth. A piece sufficiently large when stretched to half its thickness (Fig. 226, *b*), is then applied over the remaining portion of the lingual surface, and its edges are

FIG. 226



united to the contiguous rubber. Strips of red rubber are then placed over the teeth to nearly, but not quite, fill the mold. A separating cloth of closely woven cotton, or the cloth removed from the rubber after the sizing has been washed out, is saturated with warm water and placed over the rubber in the mold, when the two sections of the flask are placed together. If the packing has been expeditiously done and the rubber is sufficiently warm, it is placed in the

flask press and gentle pressure applied. The flowing of the rubber should be followed every ten seconds with a partial turn of the screw until the flask is closed. The flask is then removed from the press and separated. If there is not an excess of rubber, the cloth will easily separate from the rubber, but should there be strong adhesion, saturation of the cloth with water will facilitate its removal. Attention is again called to the danger of warping the denture while closing the flask. This is especially so with the double vulcanization method because of the small amount of rubber required to cover the lingual surface (see Chapter VI).

Vulcanizing.—The case is vulcanized in the same manner as the base-plate. Preference is given to low temperature and long time, 300° F., for three hours from the time of applying the heat. It should not be taken from the flask until cold (see Chapter VI).

FIG. 227

Finishing.—After washing to remove the loose plaster, the tin may be easily stripped off, and the excess vulcanite filed from the periphery of the denture. A sharp chisel should be used to trim about the labial and buccal surfaces of the teeth, but the lingual surface should be trimmed with a scraper. The file marks about the periphery of the plate should be removed with fine sandpaper. The labial, buccal, and lingual surfaces are buffed with felt wheels and cones

carrying pulverized pumice and water. The spaces between the teeth are best reached with a stiff bristle brush wheel, using wet pumice. All the surfaces, including the maxillary, are glossed by using a rapidly revolving soft brush wheel and whiting wet with alcohol or water.

FIG. 228

FIG. 229

Illustrations.—Fig. 227 is the completed case shown in occlusion. Fig. 228 presents the lingual aspect of the teeth and the reproduced rugæ. Fig. 229 shows the maxillary and mandibular surfaces.

Conclusion.—The double vulcanization method is best adapted to full cases, but may be used in partial cases. The tin finishing method is applicable to the single vulcanization method as well as to the double. It is the easiest and best method of forming the contour of the surfaces of the denture; also producing a dense surface on the vulcanite.

CHAPTER X

ALUMINUM BASE–PLATE

History.—Aluminum was known theoretically long before it was reduced to a pure metal. In the early part of the nineteenth century Sir Humphry Davy named the metal "alumium," signifying that it is the metal of alum. Other scientists contended that the metal should be named from its oxide alumina, therefore aluminium. In 1812 Davy compromised and called it aluminum, which name is the generally accepted one of today.

Wohler was the first to reduce it to a metal in 1827. Deville took it from the rank of a curiosity and made it one of the useful metals in 1854. Deville's process of manufacture was known as the sodium process. August 18, 1885, E. H. and A. H. Cowles, of Cleveland, received a patent for an electrical process for making aluminum alloys. In 1886 Charles M. Hall, of Oberlin, Ohio, applied for a patent, which was granted April, 1889. This process produced pure aluminum by electrolysis. This process is used by the Aluminum Company of America, whose principal plant is located at Niagara Falls. In 1855 the metal was worth nearly $100 a pound; today the purest metal on the market can be purchased, in quantity, at less than thirty cents a pound.

Physical and Chemical Properties.—Aluminum is a silvery white metal. Its specific gravity is 2.56. It fuses at 657° C. or 1215° F. Its specific heat is high. Its lineal expansion is relatively high; of the common metals it is only exceeded by zinc and lead. As a thermal conductor it is better to compare it with the other metals. Ag, 100; Cu, 73.6; Au, 53.2; Al, 31.3; Zn, 28.1; Sn, 15.2; Pb, 8.5; Pt, 8.4. Pure aluminum has good tensile strength; but is not very rigid; it will bend nearly double. It is about as hard as copper;

it is just below copper in ductility, and nearly as malleable as gold. Aluminum powder is the ground leaf. It is electropositive to all other metals used in the mouth, therefore it is the one that would be destroyed if a voltaic couple is formed. This property and its lack of rigidity unfits it for partial dentures. The impurities of aluminum are iron and silicon. The Aluminum Company of America gives the composition of their No. 1 grade as: Silicon, 0.30; iron, 0.15; aluminum, 99.55 per cent. This grade is usually 99.25 to 99.40 per cent. pure. Their No. 2 grade contains 2 per cent. each of iron and silicon. The natural solvent for aluminum is hydrochloric acid, the other mineral acids having little or no action. Sulphur at less than a red heat does not act upon it. Solutions of caustic alkalies, chlorine, bromine, iodine, and hydrofluoric acid act readily and corrode the metal. It withstands the action of organic secretions better than does silver. Therefore, it is used for dental plates, for surgical instruments, and for articles subjected to carbolic acid or other organic antiseptic solutions; but antiseptic solutions of mineral salts should not be used upon it. It is not injured by the salt and vinegar used for culinary purposes.

Aluminum Base-plate.—Aluminum is used as a base-plate both by the casting and swaging methods. It was first used for the casting method by Dr. J. B. Bean of Baltimore. He cast it under pressure of a column of the metal several inches high. Dr. C. C. Carroll, of Ravenna, Ohio, later of Meadville, Pa., and New York City, developed a process of casting aluminum under air pressure, using a rubber bulb. Dr. R. C. Brophy, of Chicago, invented a method and process for casting by jarring the molten metal into the mold. All of these inventors used alloys of aluminum, deeming it impossible to make dental castings of pure aluminum. Carroll's alloy, as given by Goddard, was Al, 98 parts; Pt, Ag, and Cu, 2 parts. Richards states that Carroll's alloy consisted of Al, 90 to 93 parts; Ag, 5 to 9 parts; and Cu, 1 part. Brophy's Aerdentalloy consists of Al, 90 parts, and Ag and Sn, 10 parts.

The writer believes that the first successful castings of

pure aluminum for artificial dentures were made subsequent to Dr. Taggart announcing his method of casting gold in January, 1907. Early in 1908 Dr. D. D. Campbell, of Kansas City, Mo., presented the "cow bell" (centrifugal) method in the *Dental Brief*, and Dr. J. H. Billmeyer of, Norwalk, Ohio, presented his methods in the *Dental Summary* and *Dentist's Magazine*. This method is undoubtedly the most successful method yet devised for casting pure aluminum. It uses the bucket and centrifugal force method, but its essential and new (to dentistry) principle is having the feed sprue enter at the bottom, and the vent sprues at the highest points of the mold. The vacuum principle is also used for casting pure aluminum, as exemplified in the Elgin Vacuum Machine.

Technique.—The technique of making a pure aluminum casting, based upon the Billmeyer method, consists of a properly taken plaster impression, investment compound cast, wax model, flasking, heating, melting of metal, casting and finishing.

Impression taking is described in Chapter II.

Investment Compound Cast.—The impression is coated with shellac varnish and glossed with sandarac varnish. It is filled with any good non-shrinking investment compound. An excellent material consists of silica sand (white lake sand), wash or float silica, and plaster of Paris, equal parts by measure. Silica is the highest fusing, the least expanding and contracting, and the best conductor of heat of any material at command. It is coarse and forms centres toward which the shrinkage of the bond material may draw, thus preventing warpage and cracking of the mass of material. The fine silica fills the pores, and the plaster serves only as a bond; therefore the strength of the compound will depend upon the quality of the bond. As a slow-setting plaster is stronger than a quick-setting one, it is evident that the poorer grades of plaster will make the stronger investment compound, but slow setting, and *vice versa*. The ingredients of the compound are thoroughly mixed by passing five times through a sieve.

It will require $3\frac{1}{2}$ to 4 parts of this compound to 1 part of water, by measure, to make a suitable mix for filling an impression. While filling the impression the material must be thoroughly jarred into place, thereby producing a smooth surface upon the cast.

The relief or vacuum chamber may be produced by either of two methods—(1) carving the impression, or (2) adding to the cast. If the addition method is chosen, a thin solution of a fine grain investment compound is painted onto the cast. To be assured that the added portion is thoroughly attached, the cast is well saturated with water over the portion to which the addition is to be made. A good formula for a fine-grained investment compound is two or three parts by measure of wash silica and one part of plaster, thoroughly mixed by sieving.

Wax Model Base-plate.—The object sought in forming the wax model for a cast aluminum base-plate is to so place the material that the finished product shall have at every part sufficient body to resist the stress to be placed upon it; to form square joints, thus no feathery edge of either vulcanite or metal; and to provide for securely attaching the teeth by means of vulcanite to the base-plate.

Technique.—A sheet of pink base-plate wax is warmed and evenly adjusted to the cast, the excess is cut away with a warmed wax knife and the edges luted to the cast. It is evident that the thickness of the sheet of base-plate wax will control the thickness of the casting, therefore a wax of suitable thickness to produce the desired result must be used. The additions to the wax base-plate are made by the use of rolls of pure yellow beeswax. These rolls are made by cutting a strip of impression wax, one-fourth of an inch wide, warming it in the flame, and working it with the fingers until it is evenly soft and in the form of a roll. It is placed upon a clean flat surface (top of the work bench is excellent), and rolled under pressure with another flat surface (a slab of glass $\frac{1}{4}$ by 3 by 6 inches is desirable). This first strip of wax should be reduced by rolling to $\frac{1}{8}$ of an inch in diameter. The roll is warmed slightly and conformed by the fingers to

the buccal and labial borders of the wax base-plate; the roll is continued to outline the lingual portion of the alveolar process. Necessarily judgment must be exercised in placing the roll of wax so that its substance will give the desired

FIG. 230

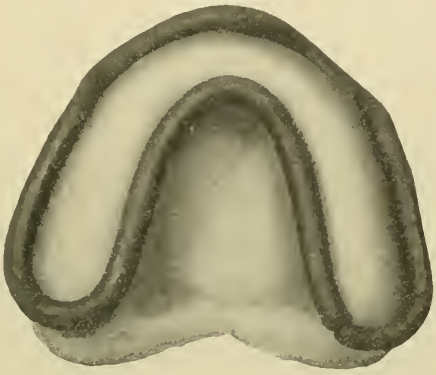
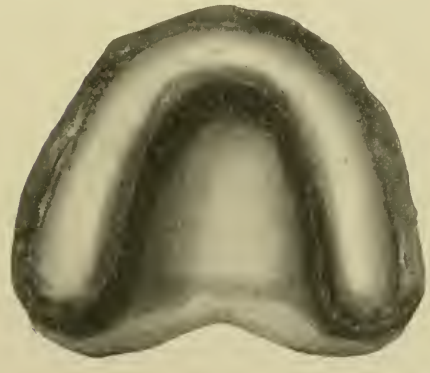


FIG. 231



contour to the model base-plate. Fig. 230 shows the pink base-plate wax adjusted and the peripheral wax as adjusted by the fingers. The roll of wax is contoured and united to the base-plate by using a hot ironing spatula. Fig. 231 shows

the wax roll so manipulated that it presents a square ledge against which the vulcanite attachment will rest in the finished denture. The next step in forming the wax model is to make provision for securely holding the vulcanite attachment to the metal casting. This is best done by means of a row of cleats as near the edge of vulcanite and casting as it is possible to place them. These cleats are formed of wax rolled to a diameter of $\frac{1}{16}$ of an inch, or less, and bent into a series of loops. This looped roll is placed upon the model base-plate and the points of contact luted by a touch of a hot wax spatula. When the wax is cold

FIG. 232

the tops of the loops are cut away with a pair of small curved scissors. Fig. 232 illustrates the attached loops upon one side of the wax model and the cleats as formed by shearing upon the other side.

The completed wax model plate is prepared for flasking by attaching gate or sprue formers. These are one feed or pouring sprue and two vent sprues. The feed sprue former is a roll of yellow wax, which must not exceed $\frac{3}{16}$ of an inch in diameter, attached near the lowest part of the wax model as it is to stand in the flask. It is obvious that the larger the feed sprue hole the more quickly the mold may be filled with the molten metal; and the smaller the sprue hole the more

danger of an incomplete casting from the metal chilling. However, as the feed sprue hole connects with the bottom of the melting crucible, there is a limit to its size. This limit of safety has been found by practice to be $\frac{3}{16}$ of an inch. A sprue of $\frac{1}{4}$ inch diameter is almost certain to permit the first molten metal to fall into and clog the lower end of the hole,

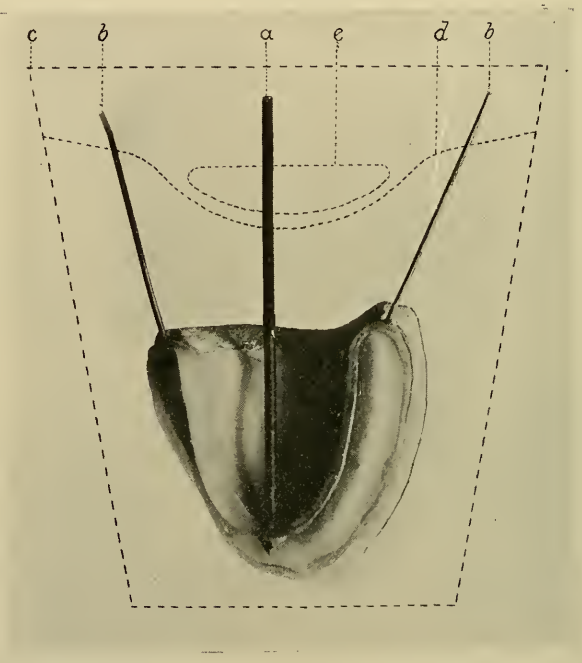
Fig. 233

Fig. 234

thereby preventing the filling of the mold. The explanation of this fact is that the specific gravity of the metal resting over a $\frac{1}{4}$-inch diameter hole is greater than the cohesion of the molten metal. The vent sprue formers are 14 or 16 B. and S. gauge iron wire attached to the highest points of the wax models. Fig. 233 shows the sprues properly attached

to the upper wax model base-plate. Fig. 234 shows the Billmeyer casting bucket or flask of sheet iron, with the handle attached. Fig. 235 is a diagram of the flask, model base-plate, sprue formers, and melting crucible.

Fig. 235

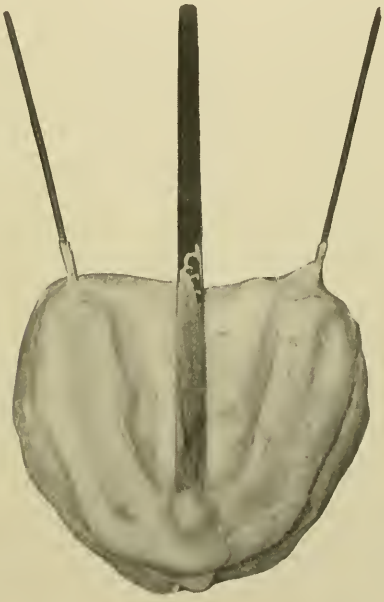


Flasking.—There are two steps to the flasking procedure—(1) investing the wax model base-plate, and (2) flasking the invested case.

The wax model base-plate securely luted to the cast is covered with water while making a thin batter of investment compound, using the same material of which the cast was made. The cast and model are removed from its bath and excess moisture quickly absorbed with a napkin. The investment

batter is applied to the wax model with a $\frac{1}{4}$-inch ox-hair paint brush. Fig. 236 shows the case invested. If the investment compound is made of slow-setting plaster, the invested piece should stand about ten minutes; but if the investment is quick setting, the second step may proceed. This will require a plaster bowlful of the investment compound of a little stiffer consistency than that applied with a brush. The material is

Fig. 236



all placed in the flask, and the invested case pressed well down toward the bottom of the flask, at the same time rapping the flask on the bench to assure the perfect adaptation of the second investment. When the investment is partially set a cavity is carved about the wax casting sprue former for the melting crucible. This is shown in Figs. 235 and 237. When the investment compound has thoroughly

FIG. 237

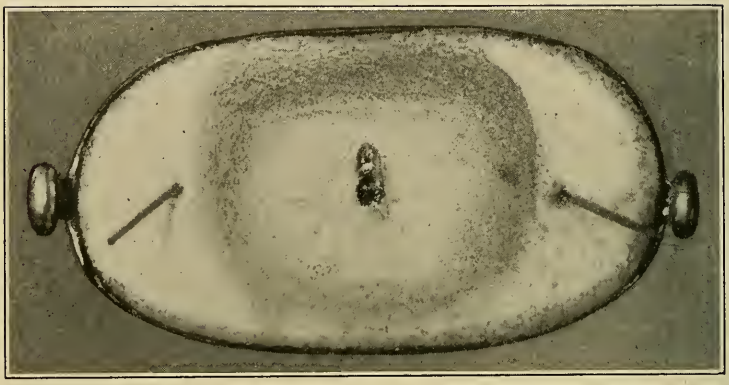
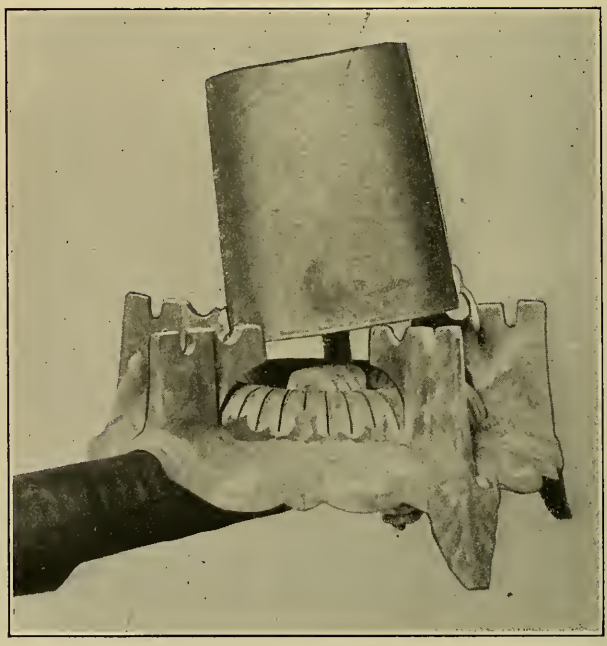


FIG. 238



set the inside of the crucible mold is scraped smooth with a round-end vulcanite scraper. This will leave the wax sprue former just flush with the floor of the crucible. All particles of loose compound must be brushed or jarred out. The flask case is placed in a warm place (not in an open flame) to dry and soften the wax; as soon as the wax begins to run, the vent sprue wires are drawn and the case inverted upon the gas stove (Fig. 238). As the wax of the model melts, it either ignites or drops upon the bench. There should be no smudge of burning wax if it is in direct contact with the flame, as the carbon, hydrogen, and oxygen are so proportioned in wax that it burns smokeless under favorable conditions. For the first ten or fifteen minutes the gas is turned on about one-half, and then for the rest of the heating up it is on full. The flask should be heated in the inverted position for one hour or until there is no flame issuing from the feed sprue hole, thus signifying that the wax is completely burned. The flask is reversed, that is, the small end is down for half an hour. Heating for another half hour will do no harm, but it is unnecessary.

The No. 1 aluminum is purchased in bars described as small notched bars (s. n. b.) containing about one and one-half pounds of metal, notched into six sections. Each section may be cut into three pieces of about equal size. One of these small pieces will suffice for any ordinary casting. The metal is very tough, therefore hard to cut. The author cuts it upon the swaging block with a cold chisel and heavy swaging hammer. The cutting is no light task.

Caution.—Aluminum is considered a connecting link between the noble and base metals, nevertheless it is base and has the property of absorbing its oxides, also, markedly, the property of occluding gases. This latter property is evidenced by the odor of garlic (carbon compound), often noticeable in a newly made casting, also the lack of uniform density shown by burnishing a buffed surface of the metal. This implies that aluminum that has once been melted in a dental laboratory should be discarded. Upon the second or third melting of the metal a yellowish tinge may be noticed;

this indicates superficial oxidation. Should the color appear with the first melting of the metal, it would indicate that the metal has been overheated, and that the casting, to that extent, is defective.

Melting the Metal and Casting.—Before placing the metal in the melting mold or crucible, the upper portion of the flask, including the crucible, is thoroughly heated with a large blue flame of the blowpipe. This precaution is to assure that the upper end of the casting mold is sufficiently heated, thus avoiding the granulated effect sometimes seen in this portion of the casting. The metal is placed in the melting mold and a yellowish tinged flame of the blowpipe played upon it until it is thoroughly melted, as indicated by the nugget of metal settling upon the floor of the crucible, although the upper surface is spheroidal. The metal has the property of holding heat, so there is no need for undue haste, but no time should be wasted in getting the metal cast. The gas is turned off the gas stove, the bail is attached to the bucket, and as it is lifted from the stove the chain is made straight. The swinging of the bucket is started with a steady long swing, avoiding a jerk at the start of the swing. The diameter of the swing is quickly reduced to the limit and the speed increased. The motion should be continued until the metal has crystallized. This will probably require from fifty to one hundred revolutions.

Philosophy of the Casting Process.—By the swinging motion centrifugal force drives the molten metal down the feed gate into the mold. By the law of physics (that liquids seek their level) the molten metal will rise in the mold and vent holes until it is on a level with the head of metal, when the centrifugal force will condense the metal until the hardness of the crystals of metal and centrifugence are equal. This will probably be when the metal has cooled 50° to 100° below its fusing point. It is reasonable to suppose that the metal that has travelled the farthest from the head of metal will be the first to set, therefore the vent sprues and the palatal border would chill, and any contraction that is taking place will be made good by the molten metal under pressure backing it

up, thereby keeping the mold full and providing a perfect fitting base-plate. The writer, by careful visual observation, has not been able to detect the defects in the castings made by this method that have been noticed in the castings made by other methods. Therefore the writer confidently presents the foregoing method as the best yet devised for casting aluminum.

Suggestions.—Sufficient free space must be provided for swinging the bucket, to preclude the bucket striking, and dumping the molten metal, thus endangering the person of the operator and nearby property. Such accidents are inexcusable. It is well for an inexperienced person to practice with a small bucket filled with water and describing the same radius as with the casting outfit. Confidence will soon be gained in the ability to start and stop the swing of the bucket. If a bucketful of water can be successfully handled, a crucible mold with nearly straight sides and only half full of molten metal should be harmless.

FIG. 239

Cooling and Removing the Casting.—After swinging, the casting bucket should be permitted to stand in a cool place

for fifteen minutes, after which the cooling may be expedited by submerging in cold water. A plaster spatula is passed

Fig. 240

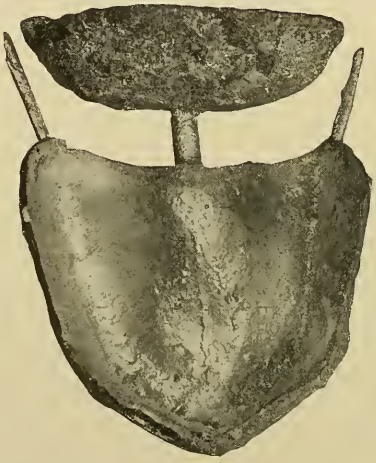


Fig. 241

between the flask and the investment, when by pressure upon the loose bottom of the bucket the casting and investment

will be pushed out of the bucket. The investment is broken and brushed away from the casting. Figs. 239 and 240 show a casting as it came from the investment. The sprues are snipped away and the edges filed. The case is sandpapered and buffed with felt and pumice the same as vulcanite.

Caution.—Cast aluminum is not elastic, therefore care must be exercised in manipulating light castings not to bend them. Probably more castings are warped by bending than by improper casting. Fig. 241 shows a trimmed and buffed aluminum base-plate.

Use of the Aluminum Base-plate.—The base-plate of aluminum is to be used the same as the vulcanite base-plate for obtaining the occlusion and contour wax models, mounting on the antagonizor, setting up the teeth, proving the antagonization and contour, flasking, packing, vulcanizing, and finishing.

All of these procedures as described for vulcanite work are sufficient for the work in hand, excepting for flasking and polishing.

FIG. 242

Flasking.—The aluminum base-plate should be so embedded in the first half of the vulcanite flask that as little of the metal will be exposed as possible; thus avoiding the scraping of vulcanite from the buffed surface. Fig. 242

shows a case suitably encased in the lower section of the vulcanite flask.

Polishing.—Aluminum may be scraped the same as vulcanite, but it may be dressed down easier with the emory cloth bands on the lathe arbor (Fig. 131). The lathe should be run at high speed, and light pressure used in holding the work against the abradent. Scratches are removed from the surface by the use of felt buffers and pumice, followed with a soft brush and whiting. This gives the aluminum a leaden polish due to fine particles of the metal and abradent being ground into the surface of the metal base-plate. There are three methods of cleansing and developing the luster of aluminum—(1) chemical, (2) use of special polishing preparation, and (3) burnishing. The chemical method consists of treating with caustic alkali and acids alternately. This method is hardly suitable for the dental laboratory. However, it gives a beautiful frosted effect, but it is doubtful if it is desirable.

Fig. 243

There are several preparations useful for the second method. Benzine and whiting rubbed on with a buffer of cotton or chamois skin, or these materials used by hand. A paste may be made of two drams each of copper sulphate and potassium carbonate and one ounce of lard. To this

paste add a dram or two of any one of several finely ground abradents, as chalk, rotten stone, rouge, tripoli, or buckhorn.

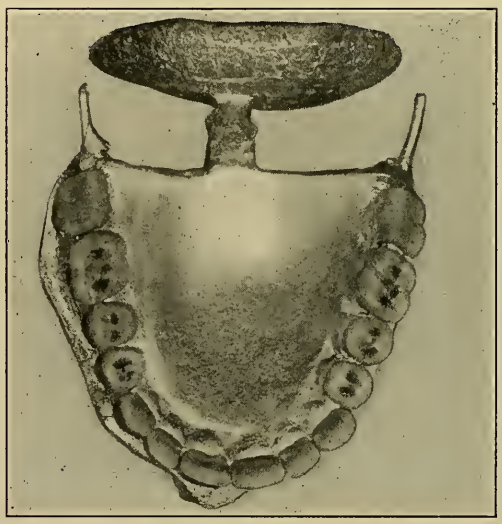
Fig. 244

Fig. 245

Fig. 246

The burnishing is done with an agate or bloodstone burnisher and a burnishing fluid composed of equal parts of olive oil and rum. This method is the very best for the maxillary and mandibular surfaces, but is open to the objection that it shows up the unequal hardness of the dressed surfaces. However, it produces the hardest and best wearing surface of any of the methods for finishing. Figs. 243, 244, and 245 show different views of completed dentures on aluminum base-plates. Fig. 246 shows the lingual surface of a denture with the metal cast to the teeth. Figs. 247 and 248 show the same case as the casting came from the flask.

FIG. 247



Casting to Porcelain Teeth.—The wax model must be so shaped that the cast metal will not overlap any edges of porcelain. The lingual surface of the denture must be carved to shape in the wax and smoothly finished. Chloroform can be used to finish the wax surface. The flasked case should be made very hot before pouring the metal; and then

Fig. 248

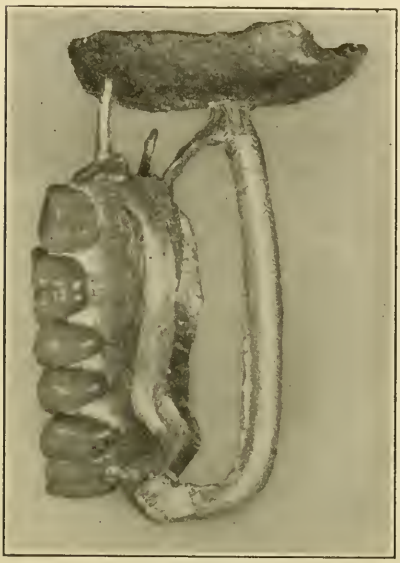
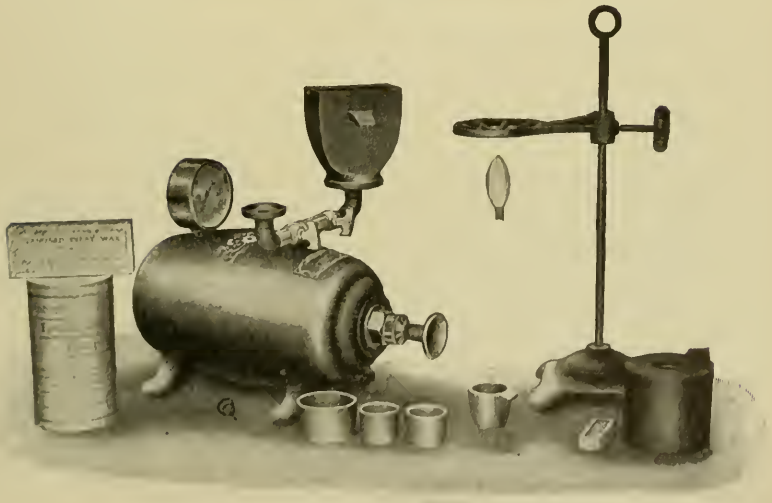


Fig. 249



the case must stand until it is cold before removing from the investment. Platinum pin teeth should not be used, as the molten aluminum is a solvent for platinum. The labial and buccal surfaces are finished with vulcanite. This method is of doubtful expediency. Fig. 249 shows the Elgin vacuum casting machine. Fig. 250 shows the method of forming the wax model and attaching the wax sprue. The process consists of drawing the molten metal into the mold by

FIG. 250

exhausting the air in the mold, through the investment compound, with a pump. It is not reasonable to expect that a light and viscous substance like molten aluminum can be cast as sharply and densely, and with as much certainty, by negative force (suction) as by positive force (centrifugal). However, many operators are much pleased with the machine and its achievements.

SWAGED ALUMINUM BASE-PLATE

Aluminum may be swaged by either the die and counter or the machine method.

Die and Counter Method.—The student is referred to the chapter on gold base-plates for methods of constructing a die and counter; it is therefore only necessary in this chapter to discuss tersely the use of such a base-plate.

Fig. 251

Formerly the most successful base-plate of aluminum was made by the swaging method; but with the advent of modern casting methods the order has been changed, and the writer

cannot conceive of any case in which the swaged base of aluminum would be preferable. However, it is well to have a comprehensive idea of the manner of using such a base-plate.

A suitable die and counter having been formed, the die is oiled (sperm or lard oil) and a sheet of well annealed No. 18 or 20 B. & S. gauged aluminum, with its fiber at right angles to the raphe of the mouth, is conformed to the die with a horn mallet, or, better, one tipped with soft vulcanite

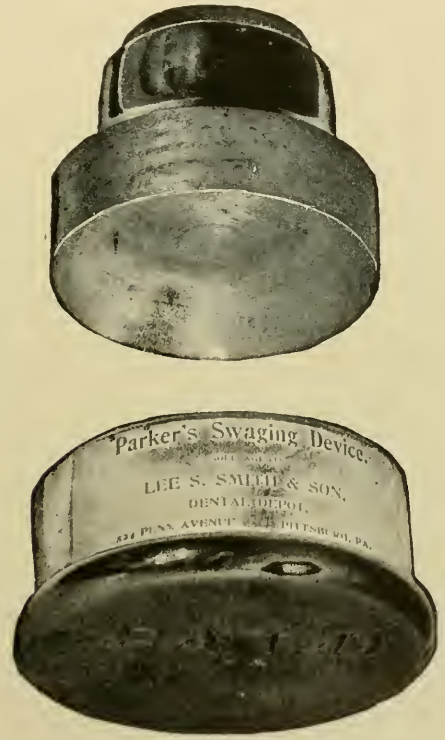
FIG. 252

(a cane or crutch tip), and then swaged in the counter-die, using a heavy swaging hammer. The direction of the grain is important, as the base-plate is easily cracked, in use, if the fiber is parallel with the raphe. The base-plate having been adjusted to the mouth, the surface is prepared to hold fast the vulcanite used to attach the teeth by scoring the surface with an engraver, or by punching loops upon the surface. The scoring is done either with a hand engraver or an automatic mallet engraver. The loops are formed with a punch. These three instruments are shown in order in Fig. 251, and the work done by them is shown in Fig. 252. The base-plate is scrubbed with soap and water to remove oil and dirt, when it is ready to be used in forming the wax occlusion and contour models. It is flasked for vulcanizing

the same as the cast aluminum base-plate. It is also polished in the same manner.

Machine Swaging.—Various machines have been devised for swaging metal base-plates; they are better adapted to the soft metals than to hard ones. The principal argument

FIG. 253



for their existence is their supposed simplification of constructing dies and counters; they certainly are not as effective as the die and counter method. However, there is a use to which they may be put in which the die and counter cannot

readily be used; that is, in reswaging a base-plate after attachments have been made to it. There are three types of these machines:

Fig. 254

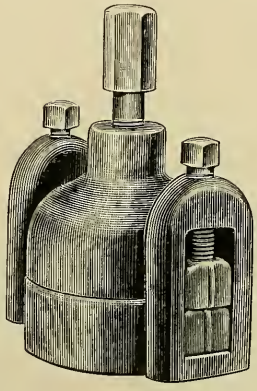
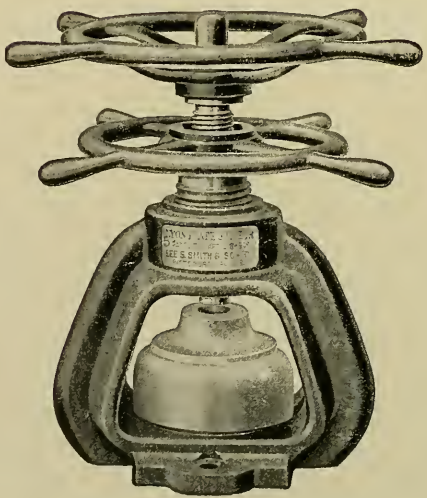


Fig. 255



Type No. 1 is shown in Fig. 253; it is known as the Parker shot swager and uses dust or No. 12 shot in place of a counter-die. A heavy swaging hammer furnishes the power.

Type No. 2 is illustrated by the Olivian swager (Fig. 254), in which soft rubber gum is used for the counter-die and the power is by means of the swaging hammer and a close-fitting plunger.

Type No. 3 is represented by the Lyon swager (Fig. 255), and differs from Type No. 2 in having screw pressure act upon the plunger.

CHAPTER XI

GOLD AS A BASE-PLATE

Material.—Pure gold is a bright, rich, yellow metal, with a specific gravity of 19.26, and a fusing point of 2016° F. It is the most malleable and ductile of the metals, and ranks third as a conductor of heat and electricity. It is insoluble in any of the ordinary mineral acids, but soluble in the combination nitrohydrochloric acid. It is not oxidized by heat alone, therefore is a noble metal. It is nearly as soft as pure lead, and can be alloyed with many of the other metals. It is used in prosthetic dentistry principally in its alloyed state. The metals with which it is alloyed for use in plate work are silver, platinum, copper, and zinc. Silver has little effect upon it, except to cheapen it and modify the color. Platinum alone with gold has little effect upon it, but in combination with silver and copper it makes the gold very hard and elastic. Copper alone hardens gold very much and gives a deep red-yellow color. Zinc makes it hard and brittle and increases the fusibility markedly.

There are two classes of gold used in plate-work known technically as *plate* and *solder*. The plate is that form of metal containing the properties of hardness or softness; rigidity, flexibility, and elasticity; high fusing or low fusing, according to requirements of the service to which it may be put. The two requirements of the other class (solder) are that it shall appear as near like the plate upon which it is to be used as possible, and melt and flow at a considerably lower temperature than the plate.

The precious metals are spoken of as so many carats fine, or so many parts of 24 pure; thus 18 k (carat) gold plate means that 18 parts of the 24 parts of the alloy are pure gold and the remaining 6 parts consist of other metals. The required carats of gold for base-plates are 18 k and 20 k, with 22 k and 24 k for special purposes. A suitable formula

for 18 k gold plate would be pure gold, 18 parts; pure silver, 4 parts, and pure copper, 2 parts. The 20 k and 22 k plate would have the indicated amount of pure gold with the alloying metals of equal amounts of silver and copper. The rigid and elastic plate known as *clasp gold* may be formed of any of the preceding carat by substituting platinum for half of the named amount of silver. Solders are formed of the same degree of fineness as plate by substituting zinc for a portion or all of the silver. This was formerly true of solders, but today, as the result of competition in trade, the solders are marked "for" the indicated carat plate. It is known that the solder is two carats lower than the number upon the solder.

Methods.—Base-plates of gold are formed by both the swaging and casting methods. Swaged gold as a base for artificial dentures has been the standard from antiquity, and especially with the modern revival of dentistry. It is especially adapted to partial cases because of the ease with which it may be built up; its rigidity, strength, and compactness; and its purity and cleanliness. For most full cases it is inferior to continuous gum. The casting method for gold bases has but one feature in which it is superior to the swaged base of gold, that is, adaptation. In all other factors (excepting purity of material) it is inferior to the swaging method. It is less dense, less rigid, less elastic, more bulky for the required strength, and consequently more expensive for stock. The casting method for gold base-plates should be limited to small saddles. It is undesirable for full dentures, bars, bands, or clasps. Gold for base-plates needs to be rolled or drawn in order to develop the properties that make it most desirable for the base of an artificial denture.

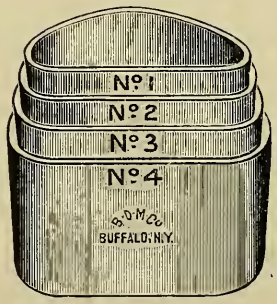
TECHNIQUE FOR SWAGING GOLD

Die and Counter Method.—The processes involved in this method are: Taking impression, making plaster cast (or, better, Spence plaster compound cast), model for die, die and counter, and swaging; making and soldering attachments.

Impression.—The student cannot be too strongly impressed with the fact that the first and most important element for success in any kind of prosthetic work is a suitable impression, and that the impression must be taken to meet the requirements of the individual case. (See Chapter II.)

Cast.—The impression may be filled with plaster, or, because of its strength and non-changing properties, Spence plaster compound. In filling the impression special attention should be given to developing the truncated cone form as directed in the chapter on casts.

Fig. 256



Model.—The model is the cast prepared for molding in the sand. The model, with the exception of its face, that is, the surface made by the impression, must be so shaped that it will readily draw from the sand mold. This will require that the entire body of the model will slant outward to its base representing a truncated cone. This may be accomplished by cutting away unnecessary plaster and building out deficiencies with wax. The thickness of the model will depend upon the kind of molding flask used. If it is a ring flask (Fig. 256), the base of the model should be one inch thick at the thinnest part to afford the required strength to resist crushing. If the molding is to be done in a Bailey flask (Fig. 257) or a Lewis flask (Fig. 258), or the die is to

be used in a swaging machine, the base of the model need be but a quarter or a half-inch thick. The base of a model so

Fig. 257

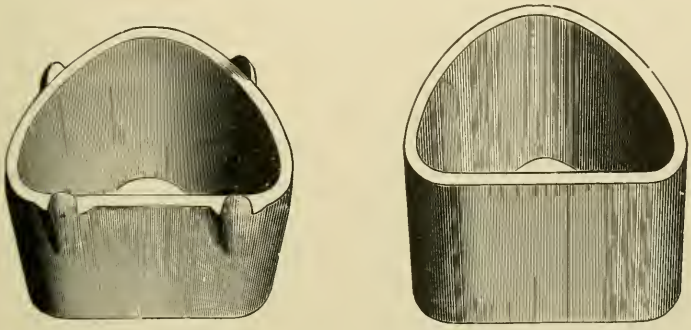


Fig. 258

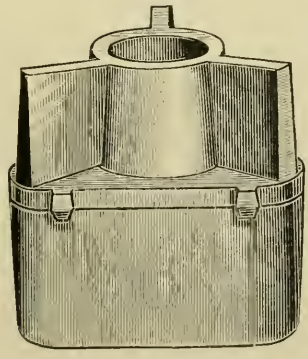
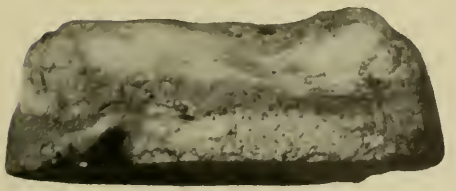
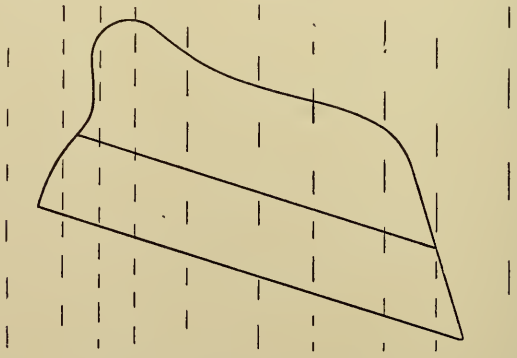


Fig. 259



shaped could furnish no obstacle to its withdrawal from the sand mold (Fig. 259). The face of the model must next be studied, to know that it will draw from the mold, or that its conformation is such it will be keyed in. It is evident that the face of the model cannot be carved to obliterate undercuts, but that means must be devised to reproduce the undercuts in the die. This may be accomplished by one of three ways—(1) by tilting the flask in drawing the model; (2) by the use of cores; and (3) by a specially constructed parting flask.

Fig. 260



The first method answers well for a single slight undercut. This is illustrated in Fig. 260. The dotted lines represent lines of gravitation. It is apparent that if the flask is held at a sufficient angle the inlock is obliterated and the model may drop without defacing the mold. The slight undercuts that may be provided for by this method are located at the incisal portion of the alveolar ridge or at one of the tuberosities.

The second method will provide for any and all cases that may present. The core is an added portion used to fill in the undercut and contour the model into a typical truncated cone. The model, having been varnished with shellac and sandarac (as desirable for molding), is built upon with a batter of investment compound (such as is used in cast aluminum work) to bring the model to the desired contour.

For strength and convenience in handling, the core should be about one-half an inch thick. It must be so trimmed that it will easily drop from the sand mold with the model;

Fig. 261

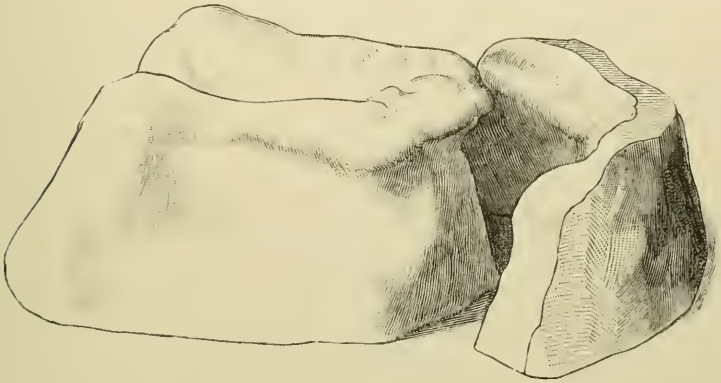
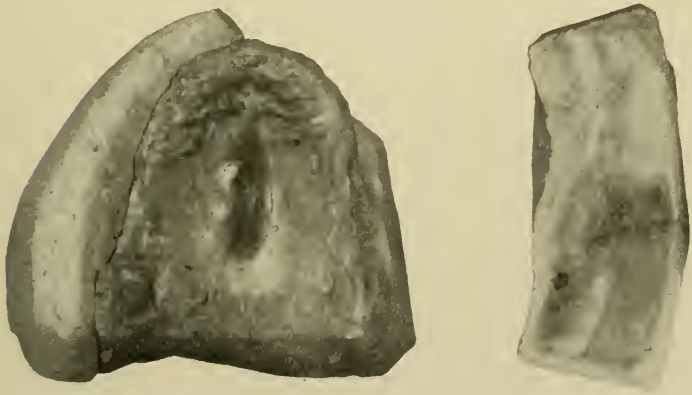


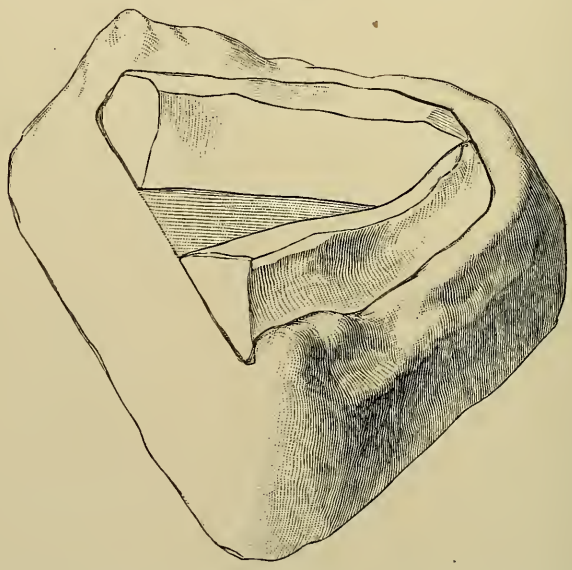
Fig. 262



the core is returned to its seat in the sand mold and becomes a part of the mold. When the investment compound has set it is parted from the model, trimmed as smooth as possible, and then placed in a warm place to dry. It should be

dried to such an extent that a temperature of 700° or 800° F. will not drive steam from it. This can be done in an hour's time by standing it on its edge upon a sheet-iron over the gas stove. The core should not be placed on its side while drying, as there is danger of warpage. Fig. 261 shows a core for the anterior undercut. Fig. 262 shows cores covering the entire labial and buccal surfaces of a model. The core may be constructed entire, and when set notched nearly

Fig. 263



through at the median line, and broken away from the model. The notch should be wide and smoothly trimmed. Fig. 263 illustrates cores for the lingual surface of a lower model.

Third method: Figs. 264, 265, and 266 represent Hawes' parting flask. This flask consists of two rings, the bottom of which is hinged to part at three points.

Molding.—There are a variety of molding sands that may be used—the iron founder's black sand, the brass founder's

brown sand, and marble dust. These materials require tempering for use. If the material is used daily it is best tempered with water, because of its cleanliness; but if it is only infrequently used, it is better to temper it with glycerin or sperm oil, as with these materials it remains ready for use for a considerable time; however, the hot metal poured upon them produces a disagreeable odor. The material is mixed with the chosen liquid, thoroughly rubbed and sieved. They improve in temper by standing a few hours. If the molding sand is in a suitable condition it will not appear moist, but a handful thoroughly compressed in the hand will break with a clean fracture.

FIG. 264

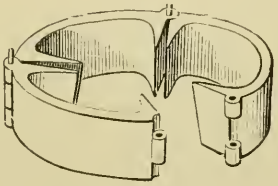


FIG. 265

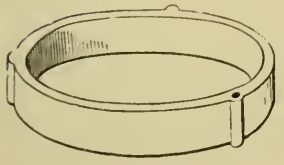
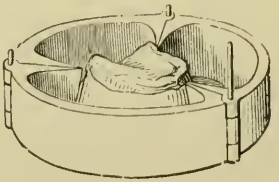


FIG. 266



Technique.—The model (with core in place if one is required) is rubbed with talcum powder, then placed upon a flat surface and encompassed with the ring of the chosen molding flask. Molding sand is sifted into the flask until it is one-third full. This is firmly packed with the fingers and a stick (tamping stick) about the model, more sand is sifted in and packed firmly down upon the face of the model. Sand is added until the ring is filled flush. The flask is lifted from the bench, turned over so that the base of the model is

upward, a thin spatula or molding trowel is passed about the edge of the model to relieve it of any overlapping sand. The flask is again turned so that the base of the model is downward; if there is a slight undercut upon the model not supplied with a core, the flask must be held at such an angle as will release the model without dragging the mold. The sand should be so firmly packed about the model that it will not drop of its own weight. The model is released from the mold by gently tapping upon the side of the flask with a light weight instrument, as a wax spatula. If the mold is not perfectly clean and smooth at the first attempt, the operation must be repeated until a perfect mold is obtained.

Caution.—If the sand is overmoist it cannot be so firmly packed without generating steam under the hot metal and thereby spoiling the casting. This may be overcome by packing the sand less firmly, but if the sand is not compact enough the weight of the metal will give a distorted and useless casting. Therefore, the student should not yield to the temptation to use insufficiently packed sand. He should use only well tempered and well packed sand.

Accessory implements that may be useful are: A 6-inch straight-edge to smooth the sand flush with the edge of the ring; a flat $\frac{1}{2}$-inch ox-hair paint brush, and a small mouth blowpipe. If needed, the occasion will suggest their use.

Metal for Die.—A suitable metal for a die should possess hardness, toughness, sufficient fluidity to take a sharp imprint, and should be moderately low fusing and non-shrinking. There are three types of metal used for dies, namely: (1) A shrinking metal (as zinc); (2) non-shrinking (as Haskell's Babbitt metal); and (3) low fusing (as the low fusing bismuth compound).

Zinc.—Zinc is the hardest of the metals commonly used for dental dies, but it shrinks the most of any of the metals. The advocates of this metal contend that the shrinkage is an advantage, that it assures a close fit. This argument is illogical, for if an impression has been taken to meet the requirements of the case all subsequent procedures should require exactness and not counterbalancing changes. The

late Professor Buckingham demonstrated that in an average-sized zinc die the shrinkage is about $\frac{1}{4\frac{1}{5}}$ of an inch across and $\frac{1}{3\,6}$ of an inch in length. Such a change would be almost intolerable upon thin, tense tissue or properly compressed soft tissues. However, the metal is much used for dies.

Babbitt Metal.—There are many alloys on the market known as Babbitt metal, some of which are little more than lead, and all of the hardware store stock is unreliable for dental purposes. The alloy made after the formula of Dr. L. P. Haskell and carried by the dental supply houses, meets the requirement. His formula consists of copper, 1 part; antimony, 2 parts; and tin, 8 parts (c-a-t-1-2-8).

Care should be used not to overheat this alloy; in fact, no base metal or alloy should be heated much beyond its melting point. There are two reasons for this: (1) Oxides are formed and occluded, which deteriorates the metal. (2) A mixture of metals heated much beyond the fusing point tends, upon cooling, to separate into definite compounds, mixtures, and pure metals, and to congeal according to the fusing point of each; thereby forming a very non-homogeneous mass. The student should be interested in the prevention rather than the cure for this undesirable condition, and exercise care in heating metals. A metal or an alloy of metals should be heated only to the desired fluidity, so as to be in the melted state as short a time as possible. As it requires considerable time for a mass of metal to liquefy, and the different portions will have absorbed different amounts of heat, and the liquefied metal is rapidly absorbing more heat, it should be apparent that when the mass is half or three-fourths melted that it has absorbed enough heat for liquefaction and should be removed from the fire. The pot having been removed from the fire, the metal is stirred with a stick of wood until the last portion of metal is liquefied. Should the metal be too viscid, it should be returned to the fire and stirred for a moment, when it will be ready for pouring.

Bismuth Compound.—Bismuth forms some wonderful alloys. They are much used in the dental laboratory. It

constitutes about one-half the weight of the very low fusing alloys. It and antimony are the only metals that expand on cooling. Hodgen states that bismuth expands $\frac{1}{32}$ of its volume. Combined with lead, tin, and cadmium, it forms alloys all of which melt below the most fusible component, and a combination may be made to fuse as low as 140° F., while its most fusible component fuses at 442° F., and its least at 617° F.

Thus the three principal substances for dies may be summed up as: Zinc, fuses at 773° F., shrinks the most of any metal on cooling, hardest, and brittle; Babbitt metal (Haskell), fuses at 500° F., non-shrinking, neither as hard nor brittle as zinc; bismuth alloy, melts below boiling water, non-shrinking, and is less hard and more brittle than zinc.

Counter-dies.—A suitable counter-die must be prepared for the die. It is desirable that the counter-die shall be of a softer and more fusible material than the die. Softness is required that the compression produced in swaging shall take place in the counter and not in the die; fusibility, so that the counter may be readily formed over the die. Lead fusing at 617° F. is an excellent counter for zinc. Four or five parts of lead and one of tin fuses at about the same temperature as Babbitt metal (Haskell), and with care in handling forms a desirable counter-die. A counter-die for the bismuth compound alloy may be formed of the same material by first "smoking" the die, or coating with whiting wet with alcohol, and careful pouring. Modelling compound serves well as a counter, or the die may be driven into the end of a block of soft pine and it used as a counter. In the swaging machines various substances are used as a counter, for the bismuth alloy dies, as shot, cornmeal, sand, tallow, paraffin, or rubber.

Pouring the Die.—A suitable mold having been obtained in the sand, the melted metal is poured in until the mold is full, when, if the Bailey or Lewis flask is being used, the top section is placed and the pouring continued until the desired thickness of die is obtained.

The casting or die should stand until it is nearly cold

before removing from the sand mold, as the metal while hot is very brittle and easily broken or defaced.

Making the Counter-die.—The die is placed upon the molding block, and sand built about it so as to cover all but the face; that is, the fac-simile portion of the mouth. The sand is built out at nearly right angles to the die for two inches. A molding ring is placed about the embedded die and pressed slightly into the sand. Sand is embanked about the encasing ring to the height of one-half inch. The counter-die metal is placed in a clean melting ladle or pot, and when half melted removed from the fire and stirred until in a viscous or "mush-like" state, when it is poured or rather dumped upon the die. There should be about twice the quantity of counter-die metal melted as needed, because, being in a semifluid state, it cannot all be poured nor placed as accurately as if melted into a more fluid state. However, the excessive quantity, viscosity, and dumping will produce a perfect counter-die without danger of fusing the die. If the counter-die metal is liquefied and poured in a small stream upon the die, there is much danger that a portion of the surface of the die will be melted and the die and counter spoiled; and a portion of the metal so contaminated that it should not be used again for either a die or a counter. Therefore, watchfulness while melting the metal and pouring while the metal is in a viscoid state will save time, metal, and vexation.

The die and counter-die should be cleaned of sand and examined for and relieved of any excrescences on their swaging surfaces. These surfaces are oiled as a preventive against any of the base metal adhering to the metal being swaged.

Swaging Gold Plate.—A suitable pattern for cutting the gold plate to size should be made. This pattern may be made of any thin pliable metal, as tinfoil or leadfoil. Tea-lead or tinfoil of about 20 gauge serves well. The supply houses carry tinfoil in rolls designed for this use. A piece of pattern foil is placed upon the cast and nicely conformed to its surface by pressure of the fingers and thumbs; it is removed

and trimmed to the outline of the desired base-plate. The pattern base-plate is then placed upon a flat surface and pressed, but not rubbed, to flatness.

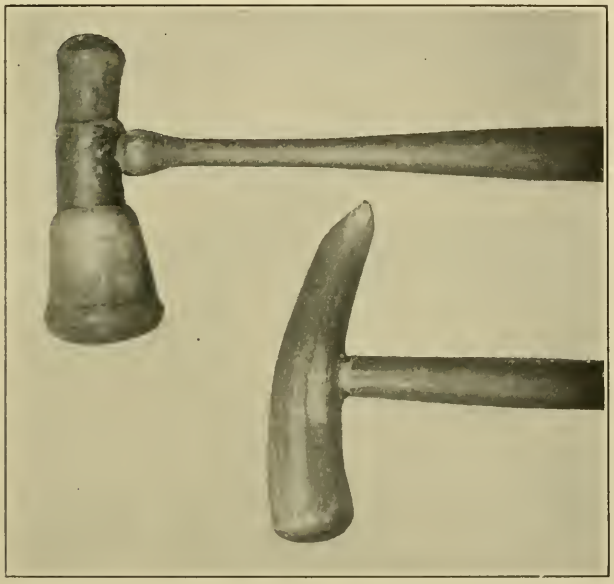
Gold plate of a suitable composition, carat, and gauge is selected for the work in hand, the pattern is placed upon it, and its outline traced with a sharp-pointed instrument. The plate is then cut to the outline of the pattern with the plate shears. It is expedient for the inexperienced workman to cut the gold $\frac{1}{8}$ of an inch larger than the pattern as an offset to inaccurate manipulation. The excess gold will be trimmed away after swaging and saved as scrap. While it is not essential, it is advisable to cut the gold so that the fiber (crystals elongated by rolling) shall be across the denture.

The gold, having been cut to pattern, is annealed by heating to a cherry-red heat and cooling in water. It is well to re-anneal the metal two to four times during the swaging process. After the metal has been upon the die it should be wiped to remove the oil and any adhering base metal that may be upon its surface before heating.

The gold is conformed to the die with a horn mallet or one tipped with rubber (Fig. 267). For a full upper base-plate the conforming is begun at the centre and extended in concentric rings outward. Care must be exercised at all times not to permit the gold to "buckle," that is, fold upon itself. Should a fold begin to form, it must be straightened out with plyers, annealed, and then malleted from the inner end outward. The plate should be well conformed to the vault before any attempt is made to carry it beyond the crest of the alveolar ridge. In fact, it is well to have a half counter-die (one made to cover the vault portion of the die only) and swage the vault portion before endeavoring to adapt the plate to the labial and buccal surfaces. The swaging is done with a heavy swaging hammer. A few dead blows should be used. The horn mallet is used with a light elastic blow, thereby marring the gold the least, whereas the swaging hammer is used with a dead pushing blow, thereby conforming without a backward spring, and with less hardening of the gold. In swaging difficult cases, that is, high vaults

and heavy undercut ridges, it is well to clamp the plate and half-counter to the die with a C clamp (Fig. 268) while carrying the labial and buccal flange to place with the horn mallet. (This illustration shows a full lower base plate.) For this part of the conforming a horn mallet with the small end filed to a blunt edge is preferable. Should the die be of the V-shape type the conforming may be more easily done

FIG. 267



by slitting the labial flange in the median line nearly to the crest of the ridge. The edges are permitted to overlap, and later are soldered. The base-plate being well conformed with the horn mallet, it is wiped of oil and base metal. As the plate must be annealed before the heavy swaging, it should be thoroughly inspected for evidences of adhering base metal from the die. Should any be detected that cannot be wiped away, it must be "pickled." The pickling is done by

boiling in a solution of nine parts of water and one of sulphuric acid, in a copper acid pan. (In forming the pickle pour the acid, a little at a time, into the water. An explosion is liable to occur if the water is poured into the acid.) The base-plate having been well conformed with the mallet, it is placed in the oiled counter-die and struck a heavy dead blow. It is then removed from the counter-die and inspected.

Fig. 268

If a buckle is forming, it should be corrected with the plyers and mallet, then returned to the counter-die and struck one dead blow and again removed and inspected. When the buckling tendency ceases it is thoroughly swaged.

It should be apparent to the student that a metal base-plate conformed and swaged over one die cannot accurately fit the mouth for the reason that the force of all the blows

struck upon the base-plate must be received upon the high points (rugæ and ridges) of the die; therefore, the elevated portions of the die are compressed or "battered down." This condition can only be offset by annealing and swaging in a well-oiled second die and counter-die.

When molding, two dies and counters should be formed, the better die and its counter to be reserved for the final swaging. If a very stiff base-plate material (as clasp metal) is being swaged, three or more dies and counters will be required.

FIG. 269

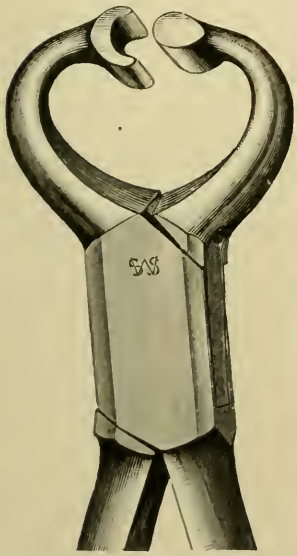


FIG. 270

Swaging Full Lower Base-plates.—The gold cut to pattern is annealed and grooved with the plate benders (Fig. 269), then conformed to the oiled die, beginning upon the lingual side of the ridge. When the base-plate has been malleted for some time it may seem quite recalcitrant, and it should then be cleaned, annealed, and swaged one stroke in the

counter, which will much aid the conforming with the mallet. In a high ridged case a half counter-die, covering the lingual surface only, will be useful (Fig. 268). The swaging is accomplished in the same manner as for the upper.

Swaging Partial Cases.—Fig. 270 shows a properly shaped model. The teeth stumps should be about $\frac{1}{32}$ to $\frac{1}{16}$ of an

FIG. 271

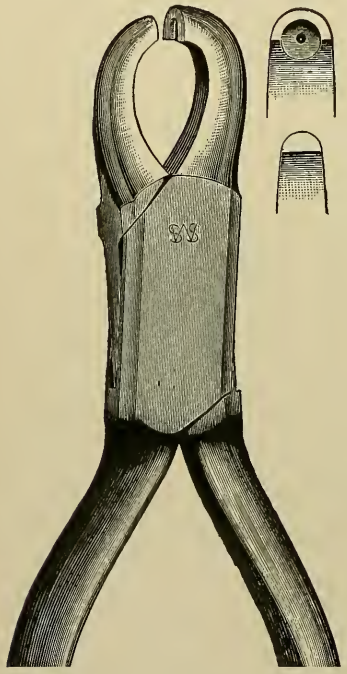


FIG. 272

inch long, just enough to give and keep a clear outline of the teeth, about which the base-plate is fitted by swaging, nipping with the plate nippers (Fig. 271), and filing with a rat-tail or half-round metal file (Fig. 272).

The counter-die for partial cases should extend but little

farther than the face of the die. Many operators embed the die for both partial and full cases deeply in the counter. This practice is worse than useless, because it is a trouble maker. In forming the counter-die, all portions of the die not desired to be covered with the counter are embedded in the molding sand. For half-counters the sand is built flush with or a little higher than the crest of the alveolar ridge, when a small molding ring is set in place and the counter-die metal poured into it.

Doublers.—A doubler is a piece of metal fitted and soldered to the lingual surface of the base-plate to give additional strength and rigidity. These are especially required for partial cases. The doubler is usually formed of the same carat and gauge gold as the base-plate, although it may be formed of a more rigid alloy than that of which the base-plate is being formed, especially if a very high carat gold is used. The doubler should be placed so as to receive the greatest strain that is placed upon the base-plate; and to interfere with the tongue and speech as little as possible. The doubler may cover but a small portion of the base-plate or it may cover nearly the whole surface. It should be at least enough smaller than the base-plate to form a ledge upon which the solder is placed while soldering, and thereby forming a less noticeable joint.

FIG. 273

Forming the Doubler.—A pattern is formed by pressing, with the fingers, a piece of pattern tin over the base-plate, and trimming to the desired form. The outline of the pattern is traced upon the sheet of metal to be used, then cut with

the plate shears. The doubler is conformed by the mallet to the first die and swaged. It is then cleansed, annealed, placed upon the base-plate over the second die, and swaged. The edge is then filed to a bevel with the bevel on the outside of the doubler. This bevelling is to aid in the finishing, as the joint between the doubler and base-plate should be as nearly imperceptible as possible. The base-plate and doubler having been cleansed by pickling, the under surface of the doubler is smeared with a fine ground or liquid flux, clamped to the base-plate with wire clamps (Fig. 273) and soldered.

TECHNIQUE OF GOLD SOLDERING

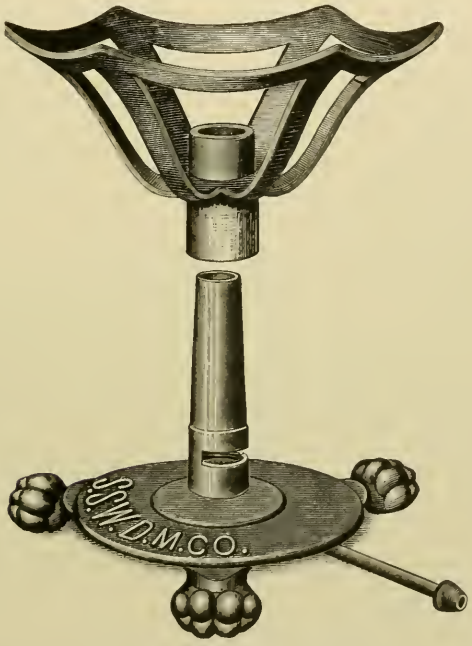
The necessary equipment for soldering gold is not large, but should be well chosen and their properties and use well understood. The necessary equipment consists of a good investment compound, holders or supports for the work, flux, and a blowpipe.

Investment Compound.—There are a number of good investment compounds on the market. Or one made after the formula given on page 341 will meet every requirement. The investment should withstand the heat to which it will be subjected without fusing or cracking, and it should conduct heat readily. Unfortunately the bond (plaster of Paris) that is used in the investment compounds fuses at a low temperature (1100° F., Price), shrinks badly, and is a poor conductor of heat. Therefore, only enough plaster of Paris should be used to give binding strength. The compound should have as few basic ingredients as possible, because it is a well-known metallurgical fact that two or more high fusing basic substances may at a moderately low temperature form low fusing compounds. Another factor to be taken into account in selecting an investment is that a material in a fine state of subdivision is more fusible than in a coarse.

Holders.—Holders are of two types, as blocks composed of charcoal, asbestos, or magnesia; and appliances serving the double purpose of holder and heater.

The charcoal block is chemically treated so that it burns only while in contact with a flame, therefore is safe to use

Fig. 274

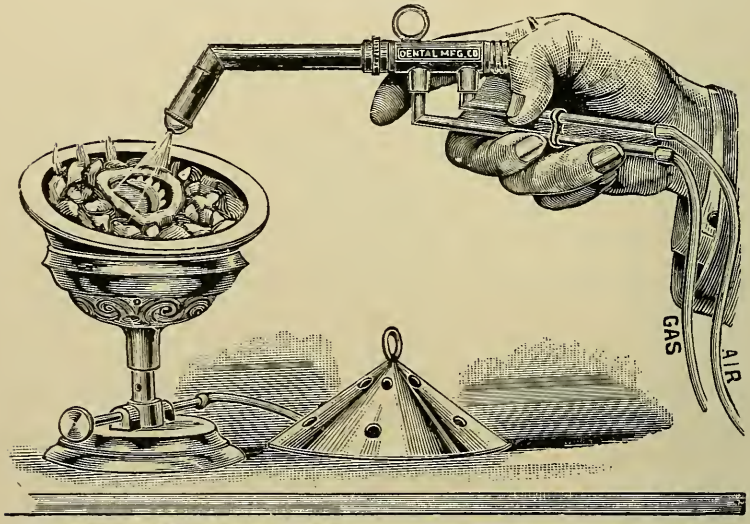


in the laboratory. This is not true of a block of ordinary charcoal. The charcoal block is the best made for certain purposes, as it adds to the heat of the blowpipe flame and aids in deoxidizing metals. Its disadvantages are that it is black, brittle (both overcome by encasing), and is rapidly consumed. It is not suitable as a support for metals to be oxidized, nor working platinum. The asbestos blocks are cleanly, durable, and fire-proof, but otherwise nothing to

commend them. The magnesia blocks are compact, cleanly to handle, quite durable, and so soft that some forms of work may be embedded in its surface and thus be better supported.

Figs. 274 and 275 show two combined supports and heating appliances.

Fig. 275



Flux.—Term derived from *fluo, fluxus,* to flow, and is applied in metallurgy to those substances that cleanse and aid the flow of metals. In hard soldering (solder that requires a red or higher heat to melt) the alkali salts (preferably sodium borate [borax]) are used—to cleanse the surface to be soldered by absorbing the oxides and preventing oxidation and making fluid the solder. For soft soldering (solder that requires less than red heat) zinc chloride and organic substances, as stearic acid, rosin, etc., are used.

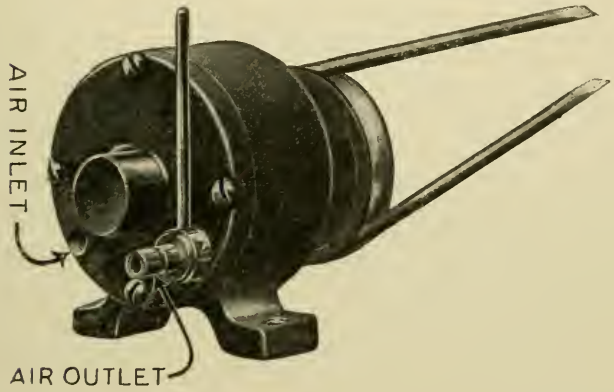
Blowpipe.—The blowpipe is an instrument of simple and complex construction, for directing, increasing the heat, and concentrating the flame in metallurgical work.

The mouth blowpipe is of the simple type, and consists of

a tapered tube either straight or bent, and is operated with the mouth by forming a bellows of the cheeks. This is an excellent instrument for light, quick service. However, it is questionable if it is profitable for the student to spend his time in mastering its technique, especially for large cases, when there are so many excellent mechanical devices for doing this work.

The mechanical blowpipe is more or less complex. There are many forms of this instrument designed to develop certain features for its use. As these various forms are described in all the reference books on prosthesis, one only will here be shown as an illustration.

FIG. 276

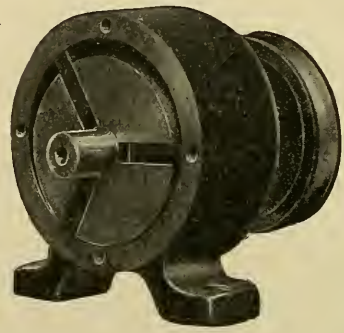


The "Automaton" (Fig. 275) is designed to be and is to an extent automatic. Gas is admitted to the pipe by the anterior tube and air by the posterior tube. The pipe is equipped with a sliding arrangement of its barrel, which automatically regulates the quantity of gas and air, provided the supply of gas and air are under suitable pressure.

The air blast is furnished either by a foot bellows, a compressed air tank, or power air pump. A very ingenius and efficient air pump known as the "Vernon Rotary Com-

pressor" has recently been put upon the market by the Lee S. Smith & Son Company. It is only 3 inches high, $1\frac{1}{2}$ inches thick, and weighs two and one-half pounds. It is designed to be coupled to the electric lathe or any small power in the office. Fig. 276 shows the complete machine and Fig. 277 its internal construction.

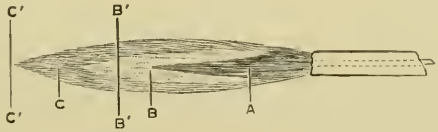
FIG. 277



Use of the Blowpipe.—On page 231 the Bunsen burner is described as a tube with an opening near the bottom for the admission of air to the gas by natural draft. In the blowpipe the air is forced into the flame, which gives a greater range of possibilities. The object of the flame is to produce heat. Heat is a result of chemical action manifested in the oxidation of the carbon and hydrogen of the fuel. It is obvious that oxidation can be controlled, hence the degree of heat and its usefulness. Therefore the object of the blowpipe is to create, direct, and control heat. The blast of air increases the amount of oxygen, the rapidity of oxidation, and heat up to a certain point, after which an increasing blast cools the combining gases until the temperature is reduced below the ignition point and the flame is extinguished, "blown out." It is impossible for the operator to tell when he has reached exactly the highest degree of heat and the flame is beginning to cool. However, he knows that a yellow tinge indicates carbon imperfectly

combined with oxygen, and that the blue color in the outer two-thirds of the length of the flame indicates perfect combustion and that the point of highest temperature is being approached or passed. (The flame is always blue at its base, but this is because the carbon has not yet reached the yellow stage.) Therefore, a yellow flame indicates a comparatively low degree of heat, and that as the blast is increased the temperature increases with the disappearing yellow color; that the succeeding blue color indicates perfect combustion, and that the temperature is increasing until the highest degree is attained, and then an increasing blast chills the flame until it is below the ignition point and extinct.

FIG. 278



The blowpipe flame, like the Bunsen flame, has three zones; the inner or gaseous zone, the middle or combustion zone, known as the reducing flame, and the outer mantle or oxidizing flame. The diagram shown in Fig. 278 illustrates the three zones, *A*, *B*, *C*. Work to be heated and soldered should be placed in the reducing flame at *B'B'*, where it will be heated, cleaned of any oxides, and the solder nicely flowed; but if the work is placed at *C''C''* or advanced to *C* the work will be made dirty by oxidation and be endangered of burning. The soldering can be done at this portion of the flame only by the use of an excessive amount of flux.

The flame is used either in the form of a brush or a needle. These are easily produced with a mouth blowpipe by having the nozzle outside of the flame for the brush form and in for the needle. The same results are obtained with the automaton by using a large flow of gas and light air pressure for the brush and a small flow of gas and a moderately heavy air pressure for the needle flame.

SOLDERING ATTACHMENTS TO THE GOLD BASE-PLATE

There are three classes of attachments, known as strengtheners, finishers, and retainers.

The strengthener may be in the form of a doubler or wire. The wire strengthener may serve as a finisher, while the finisher is always a strengthener.

Soldering Doublers.—The base-plate and doubler having been pickled and thoroughly cleaned, the doubler is smeared on the under surface with a fine ground cream or paste of borax. (If desired the proprietary fluxes in the supply houses may be used. They are composed principally of borax.) The base-plate and doubler are firmly pressed together and clamped with wire clamps. (See Fig. 273. These clamps are formed of soft iron wire, gauge 15.) Solder, two carats lower than the base-plate, is cut in pieces $\frac{1}{8}$ by $\frac{1}{8}$ or $\frac{1}{8}$ by $\frac{1}{4}$ of an inch, fluxed, and placed upon the base-plate at the edge of the doubler for one-half of its circumference. The work is supported upon a soldering block, preferably of charcoal, with the solder decked edge elevated. The yellow-tinged brush flame is applied to the base-plate and doubler with the greater heat at the farther side of the doubler from the solder. This will cause the solder to flow between the base-plate and doubler and completely fill the space between them. The solder flows between the two plates of metal in place of running away, because of three physical laws, as follows: (1) Solder always flows to the hottest point. (2) Capillary attraction. (3) Gravitation. Should every portion of the joint not be filled at the first flush, more solder should be added, at the deficient point, and flowed. No attempt should be made to remelt the first flush of solder. The case is pickled to remove the flux and reswaged in the last die and counter by two or three dead blows of the swaging hammer.

Soldering Finishers.—A gold base-plate that is to have the teeth attached with vulcanite should have a finisher provided

for the joining. However, the finisher is often omitted as a means of saving labor and expense, but always at the expense of strength and perfection. The finisher may be, in form, either thin plate or wire. Upon the buccal and labial surfaces the thin plate finisher may be formed either by turning the edge or soldering on a swaged piece of plate. Finishing the lingual surface of the joining with thin plate can only be accomplished by swaging and soldering an extra piece of metal. A wire soldered about the periphery of the joining is the neatest, strongest, and best way of forming a finisher.

Turning the Edge of Base-plate.—If a turned edge of the labial and buccal surfaces of the base-plate is desired, the impression is prepared by marking the required outline of the edge of the base-plate and carving away, at right angle to the median plane of the impression, the border of the impression to the indicated outline. This will result in the forming of a ledge upon the die that will turn the edge of the plate at right angle. The balance of the turning is done with pliers.

Swaging and Soldering the Labial and Buccal Finishers.—For this purpose wax occlusion and contour models are obtained, the case placed on the antagonizor, teeth mounted, gum portion restored either with porcelain sections or wax; when an impression is obtained of the surface for which the finisher is to be formed, the model, die, and counter formed; and the finisher swaged. The finisher will be in two sections, each extending from the median line. The teeth and wax are removed from the base-plate in a mass by warming the under surface of the base-plate. The finisher, boraxed, is clamped to the base-plate with wire clamps, solder placed in the crevice and drawn outward by the blowpipe flame.

The same procedure is required for forming the lingual thin plate finisher. However, the work is carried on at the same time (not after) as the buccal and labial finisher.

This method necessitates much labor and mechanical skill, and when completed is neither as strong nor cleanly as the wire finisher.

Wire Finisher.—This finisher is formed by using an 18 or possibly a 16 B. & S. gauged, 20 k, gold wire, and forming it to the base-plate. The conforming is done by bending the annealed wire with the fingers and pliers so as to approximate the periphery of the base-plate. Begin at either tuberosity and conform the wire for one inch, attach with wire clamps placed at both ends of the conformed portion, place a small portion (size of the head of a pin) of boraxed solder at some point of contact, and melt. Continue the conforming and tacking an inch at a time until the wire is

FIG. 279

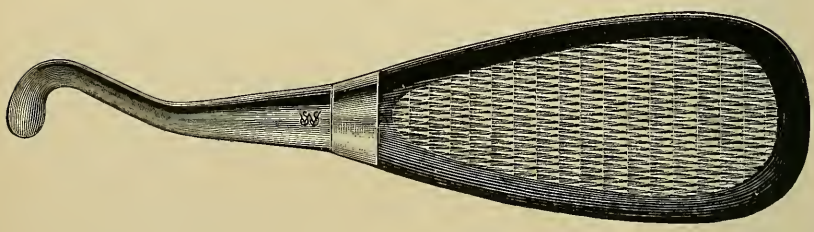
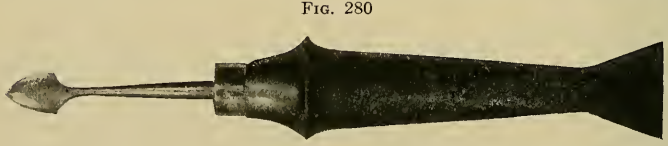


FIG. 280



carried the entire length of the joining of the base-plate, and vulcanite. The base-plate is placed upon the die and the tacked wire closely adjusted to the base-plate for its entire length. This may be done with a plate burnisher (Fig. 279 is the Prothero, and Fig. 280 is the Wilson plate burnisher), or a small copper riveting hammer may be used. The base-plate is removed from the die and inspected for base metal. The crevice is smeared with flux and a generous quantity of solder placed along the upper edge (as supported on the block) of the wire for its entire length; it is supported on a soldering block and the yellow tinted blowpipe flame applied care-

fully over the whole surface of the base-plate until the flux is dry, when the flame is placed at either tuberosity and concentrates at the lower edge of the wire, thereby fusing and drawing into place the solder, advancing piece by piece until all is fused.

Fig. 281

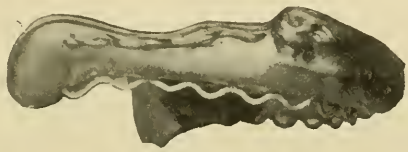


Fig. 282

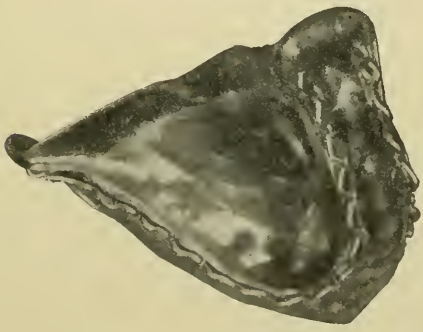
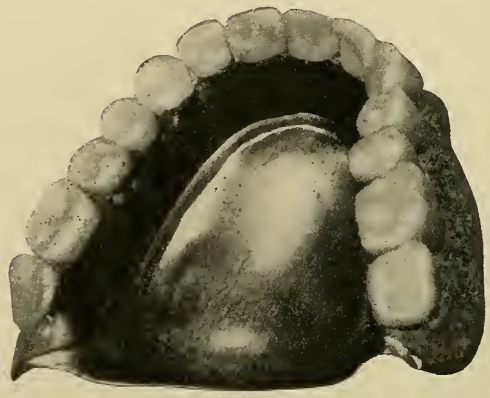


Fig. 283

Retainers.—Retainers are loops soldered to the base-plate, about which the vulcanite is attached. It is obvious that the greatest efficiency of the retainers is at the periphery of the joining. They are formed of wire, or narrow strips of scrap

gold plate, convoluted. The convoluted strip or wire is clamped to the base-plate and soldered. Figs. 281 and 282 show a gold base-plate, with the vulcanite removed, that was worn for some years. Figs. 283 and 284 show a completed denture.

Fig. 284



Warping in Soldering.—The base-plate is subject to warping by unequal expansion of the metal while soldering. This can hardly be avoided. Base-plates are often unnecessarily warped by clamping to the soldering block with a spring clamp. When all metal attachments have been made to the base-plate it is placed upon the die and inspected; if any rocking or springing appears as pressure is applied on different portions of the base-plate, it should be placed in a swaging machine, as the Parker shot swager, and reswaged.

The base-plate is now tried in the mouth, and if satisfactory, wax is built upon it for the occlusion and contour models; when the subsequent procedures are the same as for a vulcanite denture.

Soldered Gold Artificial Dentures.—Prior to the introduction of vulcanite the teeth were soldered to the base-plate. This necessarily was a very unsanitary appliance. There is no logical or practical reason why such a denture should

be inserted at this stage of the development of dental prosthetics. However, there are a few cases in which a modified form of the method may be of the greatest service. Fig. 285 shows the lingual surface of such a partial denture. The

Fig. 285

patient for whom this appliance was constructed had a very long upper lip and the lower teeth shut very close to the upper gum. Facings were backed with 26 gauged clasp gold, backings closely fitted to the base-plate, invested, and soldered. The labial gum restoration was made with

Fig. 286

vulcanite. Fig. 286 shows the labial aspect of the same case.

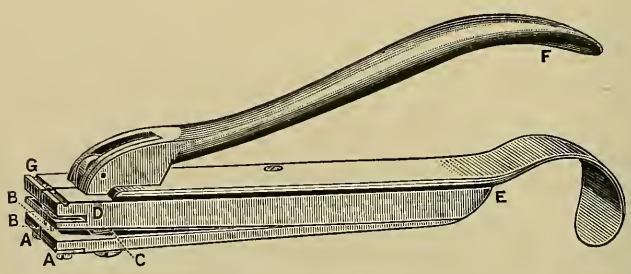
There are some partial cases which require no gum restoration, that because of the close shut will require a metal-backed facing soldered to the gold base-plate; or if the base-

plate is to be vulcanite a metal tang of clasp metal is soldered to the backing of the facing and extended backward into the vulcanite base-plate. Fig. 287 shows such a facing backed and tanged. Bicuspids for very close shut cases may be provided with a porcelain-faced gold dummy (such as is used in bridge-work) soldered to the base-plate. For molars the facing may be better omitted.

Fig. 287

Soldering Porcelain to Metal Base-plate.—This work requires that a stiff rigid plate of metal be closely fitted and attached to the facing with solder; or the facing may be backed with either 35 gauged pure gold or platinum, invested and contoured with 22 k solder. The facings, however backed, are adjusted to the base-plate and soldered.

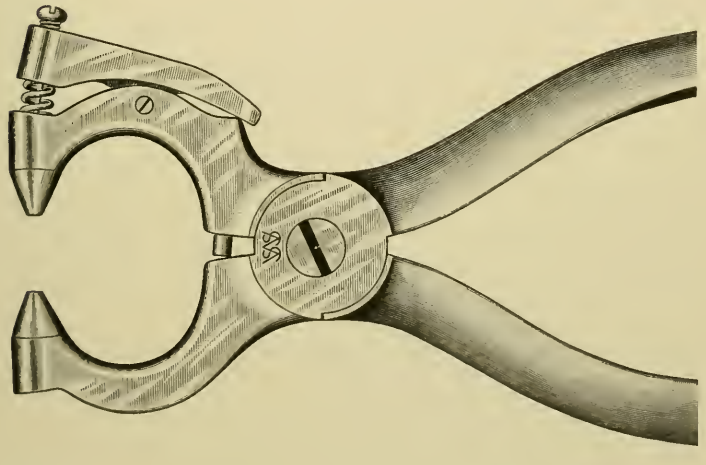
Fig. 288



Fitting the Backings.—Tinfoil patterns are made of the backings and traced upon the gold to be used. It is well, as a precaution against inaccurate workmanship, to punch the pinholes before cutting the backing from the stock piece. The English double punch (Fig. 288) may be used, and punch both holes at the same time, or the single punch

(Fig. 289) may be used and punch the holes separately. If the double punch is used the tooth to be backed will adjust the punch, while with the single punch the plate must be marked for the punch. This may be done by slightly smearing the metal with wax and pressing the pins of the tooth into it, or tinfoil punctured by the pins of the tooth may be laid upon the metal as a guide to punching. The

Fig. 289



backing is conformed to the facing as closely as possible by bending. The edges are filed to a bevel and burnished to the facing. The facing and its backing are temporarily held together by turning down a shaving from the side of the pins made by a cut with a sharp knife or chisel.

Investing and Heating.—The teeth backed and luted to the base-plate are removed from the plaster cast, invested with investment compound to a thickness of one-fourth or

one-half inch. The investment is thoroughly dried, and while warm a small amount of flux, rubbed to a cream or mixed with vaseline, is applied to the joints and pieces of fluxed solder placed upon the joint, also a small piece rested upon each pin so as to unite the pin and backing. The invested case is placed upon a combined supporter and heater (Fig. 275), and gradually heated until it has attained a dull red heat. The porcelain must be heated up through the investment and not through the metal backing. In other words, the porcelain must expand in advance of the metal pins to avoid cracking. The work having been heated to a dull red state is ready for the blowpipe. The yellow-tinted brush flame is played over the investment and gradually brought over upon the metal, and the brush flame continued until the solder begins to melt, when each piece of solder is touched consecutively with the blue needle flame and thoroughly flowed. Should any portion of the work require a large amount of solder after the first tacking, it is best done by feeding into the flame, held at the point to be filled with solder, a long strip of fluxed solder held in clamped tweezers. Care must be exercised not to hold the flame at one point long enough to melt the work. This is accomplished by interrupting the flame contact.

Cooling the Investment.—The fire is withdrawn and the case permitted to stand until cold. No precaution is required, except to protect from drafts of air, as too rapid radiation of heat might craze the porcelain. The investment compound is a poor radiator of heat, therefore retains the heat and permits the metal to cool in advance of the porcelain. The cracking of porcelain in soldering is largely due to expanding the metal pins in advance of the porcelain in heating up and cooling the porcelain in advance of the pins in the cooling-off process. Hence the principal time of danger of cracking is while heating up.

Partial Upper Dentures.—The base-plate is designed in outline to meet the requirements of the case. Modern thought requires as little of the vault to be covered with the base-plate as is consistent with strength and rigidity. Fig.

290 shows a partial gold base-plate fitted about all of the remaining teeth. Figs. 291 and 292 show a band base-plate with as little surface covered as is consistent with stability. The band should extend across and in proximity to the high-

FIG. 290

FIG. 291

est portion of the vault. Fig. 293 shows a partial denture on a vulcanite base-plate with gold clasps that is a compromise between the two preceding illustrated cases.

Partial gold base-plates may be constructed by either the swaged or cast method. However, as has been stated, the quality of adaptation is the only factor of superiority

of the cast over the swaged base-plate; and it is questionable if this closeness of adaptation is desirable; if contact with a smooth surface is not more acceptable to the contiguous tissues. As contact is almost a negligible factor in the retention of partial base-plates, the contact over the vault portion of the mouth may be ignored; except that sufficient contact must be had to prevent the sound waves of vocalization passing between it and the roof.

Fig. 292

Fig. 293

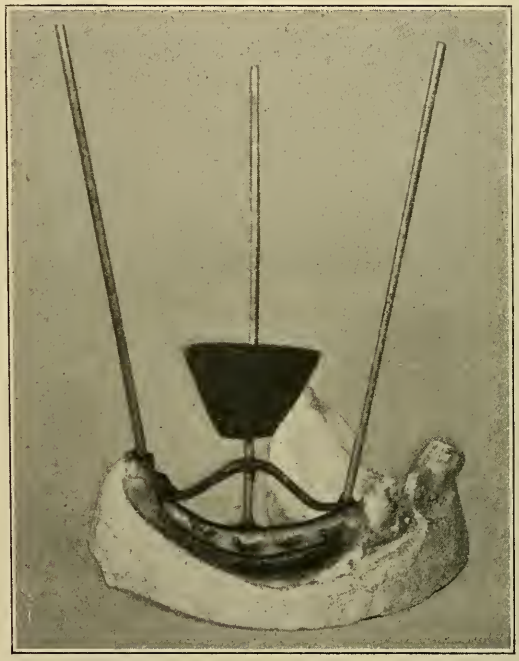
Swaged.—The model, die and counter, swaging and reinforcement have been considered. Clasps as retainers, their form, location, and construction are discussed in Chapter VII, but adjusting the clasp to the base-plate will require attention.

The partial base-plate with all of its attachments, save clasps, soldered is tried upon the die, and if found out of shape it is reswaged in the swager. The base-plate is then

pickled and cleansed and adjusted to the mouth. Should its weight be too great for its retention by contact, the maxillary surface is moistened and sprinkled with powdered gum tragacanth and held in place for a moment until adhesion is established. A plaster impression is taken sufficient to cover the portions of the teeth to be clasped and the contiguous base-plate. Should the base-plate not leave the mouth with the impression, it is removed and replaced in the impression. Another plaster impression is taken, necessarily of the teeth to be clasped only. This impression may be of the teeth individually or collectively. The impression containing the base-plate is varnished and carefully filled with investment compound. The impression of the teeth only is varnished and filled with plaster or, preferably, Spence plaster compound. Some prefer filling this impression with bismuth alloy, but nothing is to be gained over the Spence compound save time, and there is danger of contaminating the clasp metal with the base metal of the bismuth alloy. The Spence compound should stand about an hour before taking from the impression, and then another hour or more to harden. The clasps are formed over the Spence compound casts, as instructed in Chapter VII, and adjusted upon the investment compound cast containing the base-plate. Contact must be had between the clasp and base-plate either by proximity or another piece of metal called a standard. Sometimes two standards are required (see Chapter VII). If the base-plate is securely caught in the investment compound cast and the clasps are securely held by their inherent elasticity, no further investment will be required; but if the parts to be soldered are not securely held, the cast should be saturated with water and invested with the spaces for soldering as wide open as possible. The case is well dried, the joints supplied with flux and solder, and heated; rapidly if desired, as there are no porcelains to be considered. If the clasp and base-plate are to be connected by a standard the upper end should first be soldered, as otherwise the contraction of the solder about the lower end of the standard is liable to pull it away from the clasp. The soldering com-

pleted, there being no porcelains attached, the case may be rapidly cooled by placing in water. The metal is then pickled, when it is ready for the vulcanite superstructure. The base-plate without porcelains may be rapidly pickled by heating nearly to redness and quenching in the pickle bath.

Fig. 294



Casting.—Figs. 291 and 292 show two views of a cast base for a partial upper denture. The only trouble with such a base-plate is that it is crystalline, flexible, inelastic, unduly heavy, and destined soon to be out of shape. Moral: *Don't depend upon the casting method for gold base-plates.* A former statement will bear repeating. The casting method is unsuitable for full gold base-plates, bands, bars, and clasps. (The case shown is a combination of cast and solder

methods.) It is suitable for small saddles which are to be reënforced with vulcanite or soldered attachments. As gold casting will be elucidated in other books of this series, it is unnecessary to encumber these pages with that which has small practical bearing upon this department of dentistry. However, a few general remarks are relevant.

The wax model base-plate should be formed as near like the desired finished piece as possible, thus saving stock and labor. Two or more sprue hole or feed-gate formers should be attached at the highest elevations; and other high elevations liable to form air pockets should have vents provided. (The vents should not be provided for the vacuum method of casting.) The feed gates in size should be in direct ratio to the size of the mold up to the extent of practicability. The fluidity of gold should be in direct ratio to the amount of gold to pass through a given size sprue hole. By whatever method the gold is cast, pressure should be maintained until the gold is crystallized. The method advocated for casting aluminum, that is the feed gate to enter at the bottom of the mold is not applicable for gold, because of the great specific gravity and the correspondingly small feed gate permissible. Fig. 294 shows a wax model for a saddle base-plate with suitably arranged feed and vent sprue formers.

BAR LOWER DENTURES

Partial lower dentures may be made with a band of vulcanite (Fig. 308) on the lingual aspect of the remaining

FIG. 295

natural teeth; or with a band of reënforced gold (Fig. 295); or with a bar as shown in Fig. 298. The bar has the merit

of being less cumbrous and interfering with the adjacent tissues the least of any method yet devised. The method is growing in popularity with both patient and practitioner.

Technique.—The saddles may be made of either swaged or cast gold. (There is probably no place where the cast base is as applicable as for these cases.) In either case the bar should be made of clasp gold wire soldered to the saddles; after which the clasps should be formed and soldered to the saddles. As the bar with vulcanite saddles are the most commonly made, its technique will be sufficient for the method, as the slight modification required for the metal saddles will suggest itself to any workman's mind.

Material.—No. 12 B. & S gauged *clasp gold* wire is the material used. Should it be apparent that unusual strength will be required, No. 11 gauged wire may be substituted, or two wires of No. 15 or 16 gauge, soldered one above the other, will serve well the purpose.

Single Wire Method.—A plaster impression is taken and a Spence Compound cast obtained. (Care should be exercised not to deface this cast, as it is the only one required to complete the denture.) Retaining clasps are fitted to the teeth to be clasped. A line is marked upon the lingual aspect of the cast to indicate the position of the lower edge of the bar. The bar must be kept high enough not to interfere with the frenum lingua or other soft tissues of the floor of the mouth. A roll of soft wax is conformed to the cast so that its upper surface will form a ledge parallel with the line marked for the bar. This ledge of wax is for convenience in shaping and supporting the bar. A bar, sufficiently long to extend at least one-half inch into each saddle, is annealed by heating to a dull cherry-red and quenching in water. This is bent with the fingers and a pair of pliers having one oval-faced beak. The bending is continued until the bar rests upon the edge of wax and is from $\frac{1}{32}$ to $\frac{1}{16}$ of an inch from the cast. If the wire is nearer the soft tissue than $\frac{1}{32}$ of an inch there is much danger that it will in time become a source of irritation. The bar and clasps are removed and the cast is painted with liquid silex above the wax ledge and for

half an inch beyond the clasped teeth. The clasps are then replaced with just enough tension to hold them securely, and the bar set in place upon the ledge of wax. The clasps and bar are then luted together with a batter of quick-setting plaster, the plaster extending from one clasped tooth to the other. The plaster luting should rest upon the lingual

FIG. 296

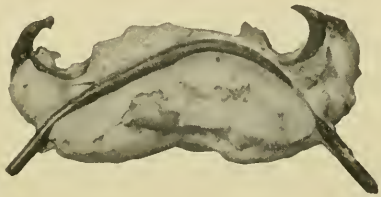


FIG. 297

aspect of the intervening teeth only to give body to the lute. When the luting plaster has become hard and strong, it is removed from the cast. It will hold the bar and probably both clasps. However, should any one or all three of the pieces of metal be parted from the luting they are easily replaced and fastened with a little wax. Fig. 296 shows

the luting plaster with the clasps waxed in place. The plaster luting is varnished with shellac and sandarac and covered with investment so as thoroughly to hold and support the bar and clasps. Fig. 297 shows such an investment with the

Fig. 298

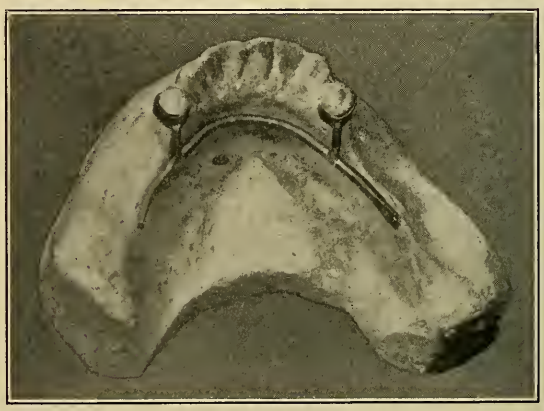


Fig. 299

luting plaster cut away and the clasps and bar united with standards. Fig. 298 shows the same case removed from the investment and placed upon the Spence compound cast. The remainder of the work of construction is vulcanite work, and should need no further description.

Double Wire Method.—Fig. 299 shows the two wires of No. 16 gauge united with wax. They are removed and invested as shown in Fig. 300, soldered together with 18 k or 20 k solder. This bar is then luted with plaster to the clasps and soldered as previously described.

Fig. 300

Too Close Fitting Bar.—Dr. S. Marshall Weaver describes a method for bending back the bar when unfortunately it presses into the soft tissues. A little wax is melted upon the bar opposite the impingement. The denture is then invested in Spence compound heavily covering all but the portion of wire opposite the wax or that portion impinging upon the soft tissues. When the Spence compound is thoroughly hard the bar is bent into the space formed by the wax, with a punch and mallet.

SOME PRACTICAL CASES

A few practical cases will offer suggestions to the student for improvising gold attachments for special cases.

Fig. 301 shows a cast with clasps attached. Fig. 302, the same case waxed ready for flasking. Fig. 293 is the finished piece.

Fig. 303 shows a partial upper to supply the teeth distal to the cuspid on one side of the mouth, with all the remaining

upper teeth closely articulated (knuckled). It was necessary to clasp the cuspid, carrying it slightly under the gum, as

FIG. 301

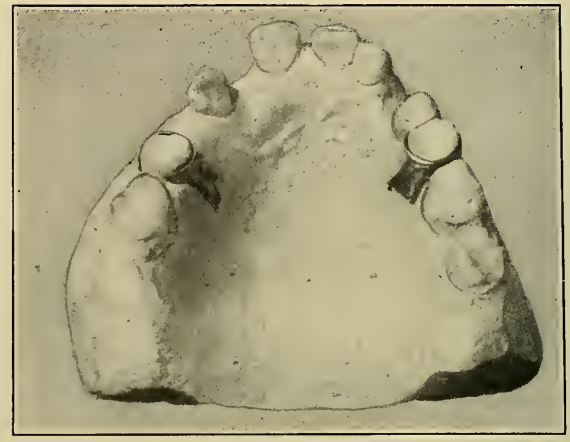


FIG. 302

that was the only way of getting a grip on the tooth; besides, the natural gum was exposed when laughing, necessitating

the clasp being accurately fitted and appearing as a cervical filling. The attachment for the other side of the mouth consisted of a crib formed by fitting a piece of clasp gold plate upon both the buccal and lingual surfaces of the first and second molars, and these joined with a U-shaped staple

Fig. 303

Fig. 304

of half-round 11-gauged clasp gold wire resting in the groove between the molars.

Fig. 304 is a bar lower for the same mouth. The teeth are missing from the cuspid backward on the opposite side of the mouth from the upper shown above. This case required a clasp upon the cuspid, but fortunately there was a space

between the second bicuspid and molar, so the crib was formed with a clasp upon both the bicuspid and the molar, with a lug resting upon the occlusal surface of the molar.

Fig. 305 shows the two central incisors with two staple cribs.

FIG. 305

Fig. 306 shows crib and clasp ready for constructing a vulcanite denture. These cribs were necessary because attachment had to be made to a fixed bridge.

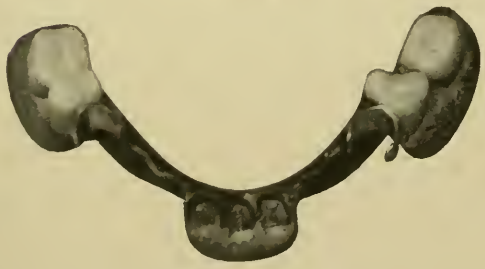
FIG. 306

Fig. 307 shows a partial lower case with gold clasps carrying three natural lower incisors. This method is possible when the teeth are recently extracted and free from

decay. Teeth used by this method are usually those lost by pyorrheal conditions. The natural teeth must not be put through the vulcanizer, as the heat and sulphur will completely disintegrate them. The tooth or teeth are cut off the desired length to fill the space and the pulp chambers enlarged to loosely admit a 16-gauged clasp gold wire. If the tooth is to be attached to a gold base-plate, the wire should be aligned and soldered to the base-plate and the tooth

FIG. 307

FIG. 308



cemented to the pin with oxyphosphate of zinc. If the teeth, as in this case, are to be attached to a vulcanite base-plate, a small piece of gold plate is soldered upon the end of each of the posts. The cervical end of the teeth are wet with water, placed upon the posts, and embedded and aligned in the softened wax. The wax is conformed and smoothed about the teeth, which are lifted off the posts, and the case completed in vulcanite. Fig. 308 shows the vulcanite base-plate ready for cementing the teeth.

Fig. 309 illustrates the metal portion of a bar lower with a cast shoe for the left bicuspids and molars, a half cope for the right second bicuspid, and spring clasps for the right second bicuspid, left second bicuspid, and left second molar. A tang is also shown for attaching the missing incisors.

Fig. 309

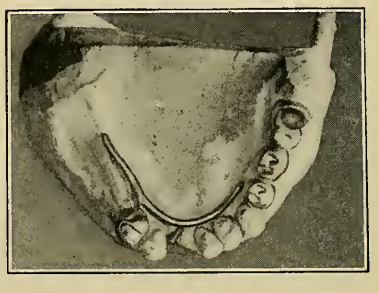


Fig. 310

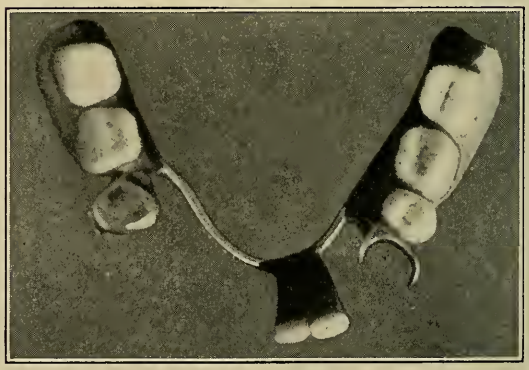


Fig. 310 is a bar lower having two incisors attached with vulcanite to a tang. It may be seen that the attachment to the right second bicuspid consists of a cope and spring clasp.

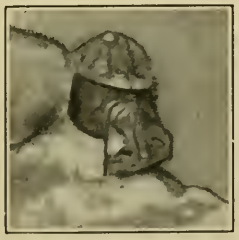
Fig. 311 has a cast ferrule telescoping three crowned teeth.

Fig. 312 illustrates the method of reënforcing the tang of

the clasp. The tang is attached to the clasp, as shown in Fig. 184, and then conformed to the cast. It is removed from the cast, supported upon the magnesia soldering block, and

Fig. 311

Fig. 312



the reënforcement of wire or a piece of scrap gold plate soldered on. This reënforcement is necessary to prevent the clasp (in time) breaking from the tang.

REPAIRING GOLD PLATE WORK

If the denture to be repaired is soldered work only, it is simply repaired. If it is combination work of gold and vulcanite and the gold is broken it will be necessary to

remove the vulcanite, solder and rebuild the vulcanite portion. If it is a clasp broken, which often happens, it may usually be repaired by fitting another clasp to the tooth, soldering a lug to it to fit into a filed groove in the contiguous vulcanite, and attaching with vulcanite.

CHAPTER XII

TIN AS A BASE-PLATE

The cheoplastic or tin method for forming base-plates was given to the profession about 1855 by Dr. A. A. Blandy. Recognizing that a casting process would provide the most perfect adaptation, and that pure tin was an acceptable metal to the tissues, the profession readily accepted the method. The later methods have been somewhat more simple than the earlier one.

The metal consists of tin alloyed with such metals as bismuth, silver, gold, and possibly cadmium and antimony. Several of the alloys on the market were proprietary, and their composition not published. The formulas of the published ones are:

Kingsley's alloy: Tin, 16 ounces; bismuth, 1 ounce.

Reese's alloy: Tin, 20 parts; gold, 1 part; silver, 2 parts.

Bean's alloy: Tin, 95 parts; silver, 5 parts.

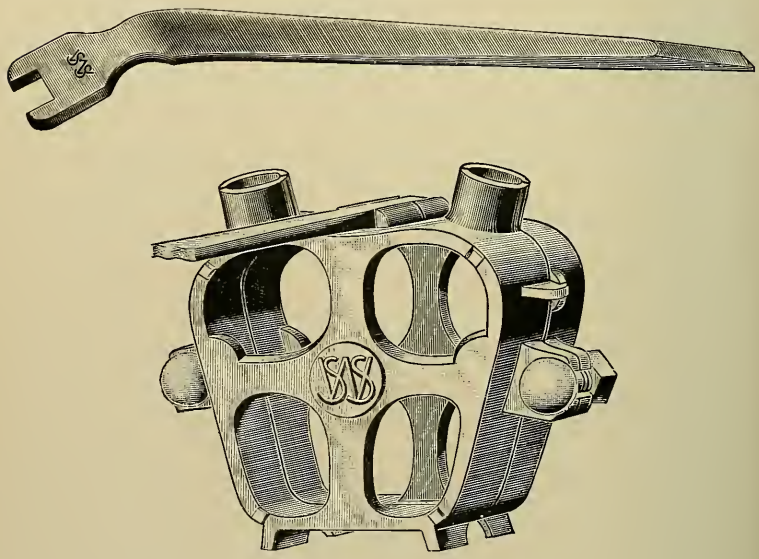
Watt's and Weston's alloys, proprietary preparations, are the principal ones on the market. These are both low fusing (about 400° F.) and interchangeable in manipulation. The method is mostly confined to lower dentures. Since the introduction of successful casting of pure aluminum there will be less occasion for its use. As the aluminum casting is better understood, it should entirely supersede the tin alloys, as it is much stronger, more cleanly and durable than the tin alloys.

Technique.—The same investment compound used for casting aluminum serves for the tin alloys. The necessary implements are a Watt's flask (Fig. 313) and a ladle or large spoon.

The wax model is formed the same as for an aluminum base-plate, flasked in the first half of the flask (Fig. 314),

paying no attention to the gates *B* and *C* at this time; and when the investment is hard, varnish and fill the second half, having the wax model wet and jarring the investment compound well into place. The flask is opened the same as a vulcanite flask (Chapter VI) and wax removed. The investment material is removed from the funnels and a small and large gate cut as shown at *B* and *C* respectively. The two sections of the flask are placed over a piece of sheetiron

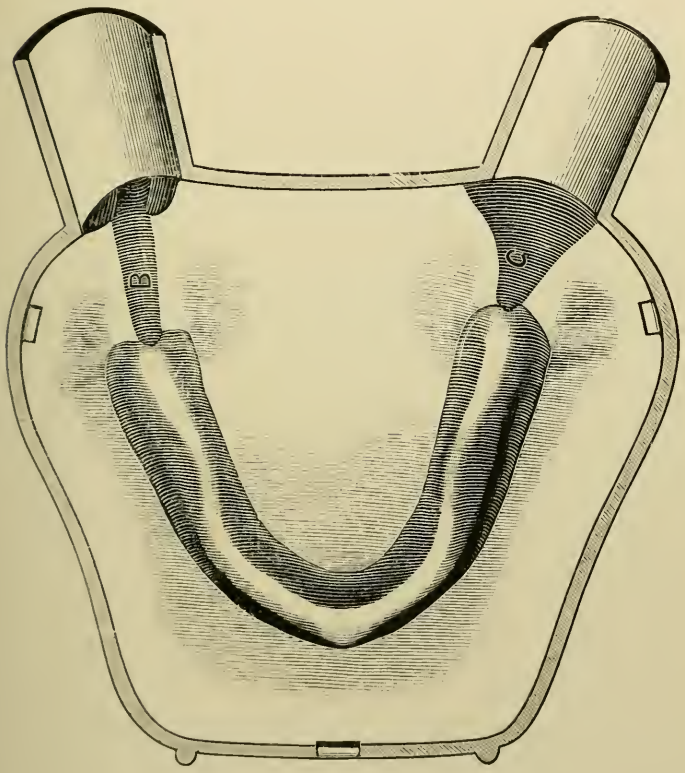
Fig. 313



on the gas stove and dried until no steam is given off. They are then bolted together, and an ingot of the tin alloy melted in the ladle or spoon over a Bunsen burner and poured into the large gate until the metal appears at the small gate. Should there be any bubbling the flask should be grasped by the handle and slightly jarred against the bench until the bubbling ceases. The casting should stand until it is cold, and then be opened. However, after the metal has

partially cooled, it may be placed in cold water and the cooling expedited. The sprues are cut from the casting

Fig. 314



with a mechanical saw, and the filling done with a vulcanite file. It is polished the same as vulcanite.

CHAPTER XIII

CONTINUOUS GUM DENTURES

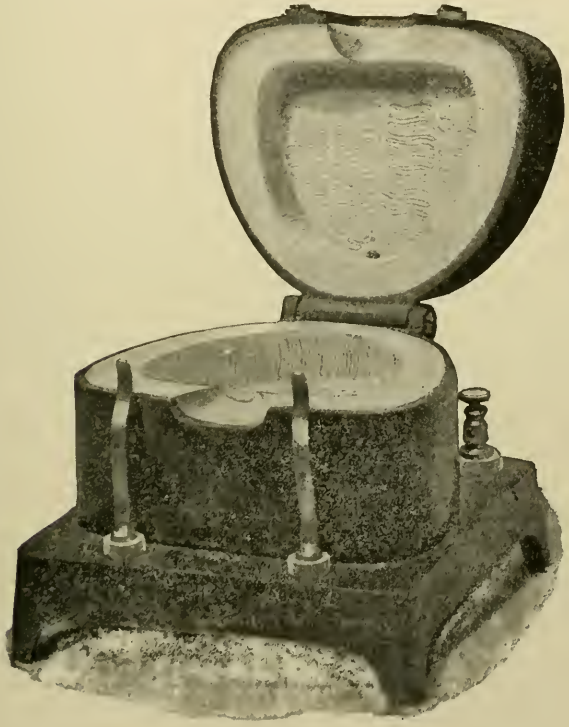
By this term is meant a base-plate of platinum, the outer surface of which is covered with a continuous layer of porcelain.

It is true, the term might equally well, or better, be applied to vulcanite or celluloid; but the term was applied to the enamelled platinum before the introduction of the other materials, and is universally accepted as applicable to the enamelled platinum only; therefore, to call any other material by this name is a manifest deception.

The French were the earliest experimenters in porcelain work for artificial dentures; but it remained for Dr. John Allen, of Cincinnati, and later of New York City, to perfect the material and method of construction. He perfected the process in 1846. The furnace work of the early days was difficult and hazardous. Within a decade of the invention of continuous gum work vulcanite was placed before the profession. Because of its inexpensiveness and ease of construction it nearly drove the more expensive and better methods from the field. However, in the last quarter of a century the facilities for constructing dentures of the better quality have been so much improved that they are gradually coming into their own. So much so that any student who is desirous of equipping himself for practice among the better class of patients should be thoroughly conversant with the construction and merits of continuous gum dentures. It is without doubt the most cleanly, healthful, and esthetic of any material or denture placed in the mouth. It is composed of mineral matter only and these of the greatest purity and compatibility to the human economy. The materials entering into its composition are platinum, iridium, gold, and high-fusing porcelain.

Porcelain.—Porcelain suitable for this work is procurable at the supply houses. It is known as "Continuous Gum Body" and "Gum Enamel." The body is in boxes containing one ounce each, and the enamel one-half ounce to the box. Close's product (modified Allen formulas) is the one

FIG. 315



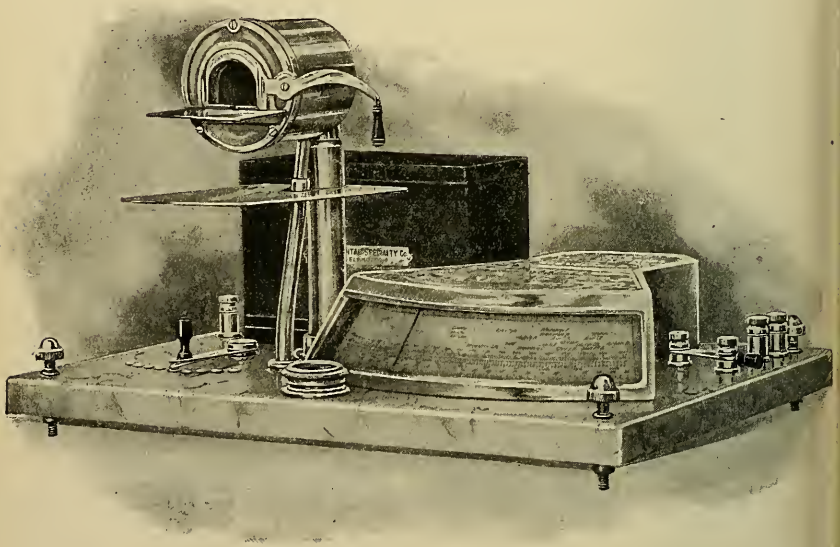
most commonly used. The body fuses at 2300° F., and the enamel about 100° lower. They are of the same composition, with more flux, as porcelain teeth.

Equipment.—For an office equipped for gold work nothing is required except a furnace for baking the porcelain. If

the electric current is to be had, one of the various electric furnaces upon the market is to be preferred; otherwise a gasoline burning furnace, of which there are several makes.

To Dr. L. E. Custer, of Dayton, Ohio, belongs the credit of inventing and demonstrating the first dental electric furnace. His first demonstration was before the Ohio State Dental Society, in 1894. Since that date other furnaces

Fig. 316

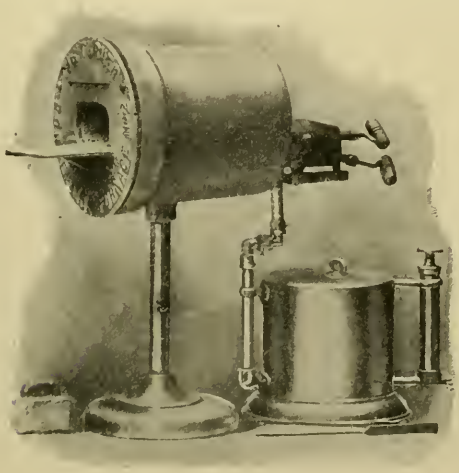


possessing excellent features have been invented, but none have surpassed the Custer furnace in scientific construction. Fig. 315 shows the furnace and illustrates the method of wiring so as to produce an economical and evenly distributed heat.

An auxiliary instrument to the furnace is the pyrometer. To Dr. Weston A. Price, of Cleveland, belongs the credit of adapting this instrument to the dental furnace. Fig. 316

shows the Price furnace and pyrometer complete. The instrument is the thermopile adapted to this special use, and requires little experience to fuse the porcelain well; however, judgment must be exercised even with this perfect instrument. Without the pyrometer the operator must depend upon his eye to determine the heat. Either with or without the pyrometer the operator must have a definite method of manipulating the rheostat, and use judgment. The voltage

FIG. 317



of any current varies within certain limits, which will have an influence indicated by the pyrometer, and in connection with the rheostat can be better controlled than by the eye. Nevertheless, an operator of average discernment and ability should, with a little experience, be able to produce excellent results with an electric furnace, either with or without the pyrometer.

Fig. 317 shows one of the gasoline furnaces.

TECHNIQUE OF CONSTRUCTION

Plaster impression, cast, model, die, and counter-die are required, the same as for a full gold denture.

A base-plate of pure platinum 32-gauged (B. & S.) is formed. Care should be taken (well-oiled die and counter) not to contaminate the platinum with base metal. The base-plate swaged and trimmed is tried in the mouth and tested for palatal length, and freedom from impingement upon the muscle attachments. The peripheral border perfected and the adaptation inspected, it is returned to the die for forming a reënforcing piece for the palatal border. Should the adaptation not be satisfactory, it must be corrected, at this stage of construction, even to the extent, if necessary, of obtaining a new impression and constructing a new die and counter.

The palatal reënforcement should be $\frac{1}{4}$ of an inch wide in the median line and slightly taper toward and terminate at the tuberosities (Figs. 321 and 328). This doubler is swaged of 30-gauged (B. & S.) pure platinum. After being swaged it is placed upon the base-plate and swaged. The anterior border of the doubler is turned up with pliers at an angle of 45 degrees so that in the finished piece the porcelain will be engaged under this edge of the doubler. The doubler will be distorted in bending the edge; this is corrected by wiping, pickling, annealing, and burnishing the doubler to the base-plate. The bending and burnishing are alternated until suitable adjustment is obtained. The base-plate and doubler are cleansed and clamped together with wire clamps, pure gold, 35-gauged, cut in small pieces, is placed, without flux, under the turned edge and melted with the blowpipe so as to draw the gold as solder outward and perfectly attach the doubler to the base-plate. An 18-gauged iridioplatinum wire is soldered with 35-gauged pure gold to the periphery of the plate, from tuberosity to tuberosity, in the same manner as wiring a gold plate. The charcoal soldering block should not be used, as carbon is

detrimental to platinum. The magnesia or abestos block will serve the purpose. Flux is unnecessary as a cleanser, as noble metals only are used; but it may serve to hold the solder in place. No more gold should be used in continuous gum dentures than is necessary to unite closely fitted joints. Some advocate the use of platinum solder (gold with 20 or 25 per cent. of platinum) and the oxyhydrogen blowpipe for soldering platinum for continuous gum dentures. This is quite unnecessary, as the pure gold will alloy with the platinum base-plate while baking the porcelain; however, close-fitting joints are necessary, probably more so with pure gold used as solder than with platinum solder.

Fig. 318

The reënforced platinum base-plate is used in obtaining the wax occlusion and contour models; and mounting upon the antagonizor. Teeth suitable for the case (Figs. 205 and 318) are selected and mounted in wax. The case is ready for trial in the mouth. It should be inspected for adaptation, contour, and cosmetic effects, which being satisfactory, the case is ready for soldering the teeth to the base-plate.

Soldering the Teeth.—It is quite essential that the waxed trial denture should be well contoured to develop all the restorations required. A record is made of the thickness of

the gum portion at the median line, at the centre of each cuspid eminence, and of the buccal contours (if any are required) by measuring with calipers and making indicative marks on paper. The wax is cut away with a warmed wax knife, from the labial and buccal surfaces, leaving the wax on the lingual surface intact to support the teeth while investing (Fig. 319).

Fig. 319

An investment suitable for this work is composed of any coarse silica compound and approximately one-fifth of its bulk of asbestos; either the long fiber or the short (tenax) fiber may be used. A soft iron wire ring of 15 gauge is formed to place about the denture in its largest plane and be free of contact by $\frac{1}{4}$ of an inch at every point. A sufficient quantity (half-bowlful) of investment is wet up to a soft putty consistency. The intaglio of the denture is filled and a portion quickly spread over the labial and buccal surfaces of the teeth; the balance of the investment is spread on the flat surface, upon which plaster casts are formed; the partially invested case, with its exposed surface upward, is pressed into it so that the most prominent points are covered by at least $\frac{1}{4}$ of an inch; the wire ring is placed about opposite the cervical portion of the teeth; and the spatula used to

draw the spread-out investment up over the wire ring and the morsal ends of the teeth, so that all will be strongly covered. The wire serves two purposes, as a strengthener and as a guide to thickness. When the investment is hard it is set in a warm place to dry and soften the wax, which is picked out and the pins of the teeth bent upward. Fig. 320 shows the invested case with the lingual surface of the base-plate and the teeth exposed; also some of the pins are seen bent upward.

FIG. 320

Reënforcing Wires. — A 12-gauged iridioplatinum wire is bent to fit closely under the pins of the teeth and with the ends in contact with the tuberosities. The long platinum pins of the teeth are bent around the reënforcement wire, thus holding it securely in place. The ends of a truss wire, of iridioplatinum 18-gauged, is placed in contact with the reënforcing wire in the proximity of the cuspids, and with its centre resting upon the base-plate in the median line

near the crest of the alveolar ridge. A small piece of pure gold (for solder) is placed at each point of contact of the wires, pins, and base-plate. The case is heated up to bright redness, when the gold is thoroughly fused with the needle flame of blowpipe. Figs 321 and 322 show two views of

Fig. 321

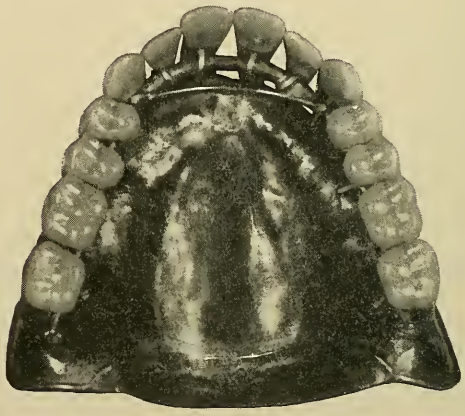


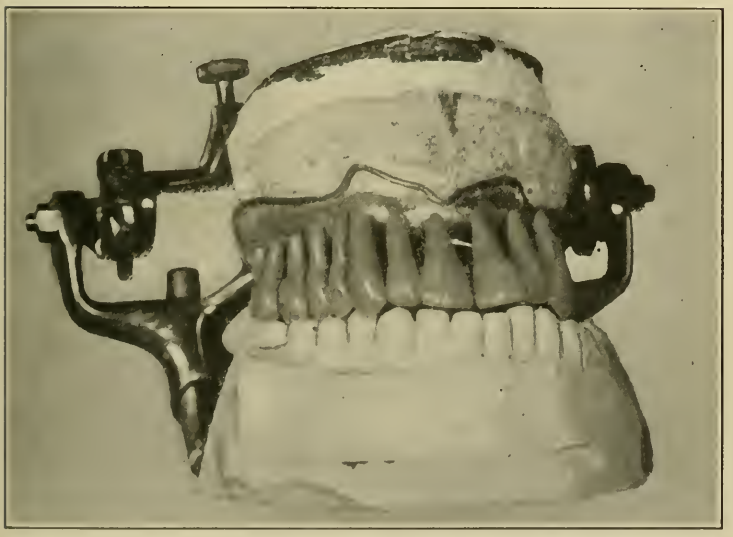
Fig. 322

the case, soldered and removed from the investment; thus giving a better idea of the palatal reënforcement, peripheral finishing wire, lingual reënforcement, and truss wires as soldered together. The case should be tried upon the die, and if warped it must be readjusted by pressure with the

fingers, and by the aid of the horn mallet, copper hammer, and plate burnisher. However, if the case has been properly

Fig. 323

Fig. 324



handled there should be no warpage. The skeleton denture is cleansed with a laboratory plate brush and water. It is placed upon the antagonizor for assurance that the teeth are in proper occlusion.

It is apparent that the peculiar formation of the porcelain, teeth, designed for continuous gum dentures, is for a purpose. The single long pin is to furnish a flexible attachment, and the root portion of the artificial tooth is to provide contact with the base-plate; also as an aid in contouring, and in controlling the shrinkage during the enamelling. When testing the occlusion, if any of the teeth are found misplaced, they may be brought into position by bending the platinum pins, although soldered to the reënforcement wire. At the same time the root portion of the tooth should be in contact with the base-plate; nevertheless, if either end of the tooth is to be out of the ideal position, it should not be the morsal end. Fig. 323 shows a case wherein the apices could not be in contact with the base-plate, and Fig. 324 shows the occlusion.

APPLYING THE PORCELAIN

Body.—A portion of continuous gum body (about one-fourth ounce) is saturated with water to the consistency of stiff mud, and a portion applied with a thin spatula to the base-plate about the apices of the teeth. The case is lightly held by the index finger and thumb of the left hand, and the body jarred and settled into place by tapping with a light instrument upon the periphery of the base-plate. More body is added and jarred until all space between the base-plate, reënforcement wire, and teeth is compactly filled. The excess moisture upon the surface, after each jarring, is absorbed with a napkin. The buccal, labial, and lingual surfaces are covered with the body; a portion at a time is covered with the napkin and compressed between the thumb and finger, the finger in apposition to the maxillary surface. Care should be exercised that no portion is more thickly covered than is desired for the completed denture, and no

attempt should be made at contour. Any body material upon the base-plate or teeth when not required must be removed. A pointed thin blade spatula and a small ox-hair brush will be useful, also an artist's medium small pencil brush moistened and drawn to a point (between the lips) is useful in making a clean cut gum outline.

FIG. 325

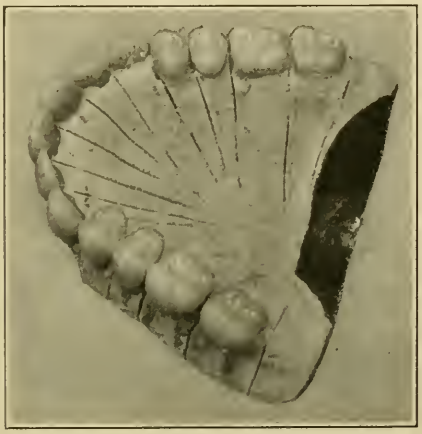


FIG. 326

Controlling Shrinkage.—As porcelain shrinks about one-sixth of its volume in fusing, it must be controlled, or the teeth will be drawn out of place. It is controlled by slitting

the body so that it will draw about fixed centres. This is done with a thin spatula, cutting entirely through the body to the base-plate, thus making each tooth a fixed centre. Fig. 325 shows the lingual surface slit. Fig. 326 shows the large spaces formed on the buccal surface by the slitting, and shrinkage in baking.

First Baking.—With a Custer furnace, the case is placed in the furnace with the teeth upward. The lever of the rheostat is advanced one stop and the case given ten minutes to dry, after which the lever is advanced two stops every five minutes, and upon the last stop it is left for one to ten minutes, as may be necessary to produce the "biscuit" bake; that is, granulated with a very slight glazed appearance. The time will vary with the condition of the current and the number of times the furnace is opened for inspection. If a pyrometer is being used the lever must be advanced to bring the heat to the desired temperature in a given time, which should be established for each current supply and furnace. Every make of furnace will furnish instructions for use. The current is turned off and the furnace opened for a minute or two to stop the fusing, when it is closed until cold. The denture is placed upon the cast, and if warped it must be corrected. The anterior edge of the palatal reënforcement is burnished down. Checking of the body does no harm.

Second Body.—The case, being cold, is wet and body applied to fill all spaces caused by shrinkage, jarred, and excess moisture absorbed with the napkin. Body is then added to form all contours. The crest of each eminence should be the full thickness of its corresponding caliper record, for the shrinkage will provide space for the glazing enamel. Any large restoration will require exaggerated body additions, as the shrinkage will be greater than the enamel added.

Second Baking.—The case is placed in the furnace, dried, and heated up the same as the first time, but carried to a higher degree of fusion than the first time (probably about 50° F. higher). The fusion is checked, and furnace closed until cold.

The case is examined for shrinkage; if there are small shrinkage spaces only they are filled in with body and not baked, but if there are large crevices the case should be baked again at about the temperature of the first bake.

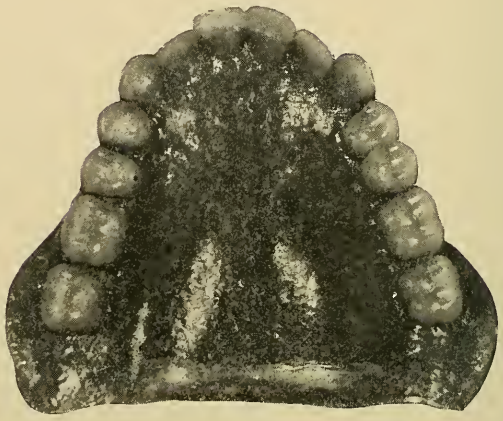
Enamelling.—As all contours, including gum margin, festoons, and rugæ, with their corresponding depressions, were developed in the second coat of body, it is necessary only to place over the surface a smooth layer of gum enamel to produce the light and dark shading characteristic of artistically constructed continuous gum dentures. The entire surface of the body should be covered with the gum enamel wet with water and smoothed with an oval-faced burnisher. The gum margin must be neatly pencilled and all granules of the gum material removed from the teeth.

Third Baking.—Ordinarily two bakings only will be required for the body and one for the enamel. The enamel coat should be heated up with the same care as the body and fused until the surface has a "watery" appearance when looked at, across the surface, in the hot furnace. The furnace is opened long enough to stop the fusion, closed, and left until cold.

FIG. 327

Polishing.—The porcelain will come from the furnace with a perfect polish, but the platinum may be buffed with the felt buffer and pumice, and glossed either with the soft brush wheel and whiting, or burnished. Figs. 327 and 328 show the completed work.

Fig. 328



REPAIRING

Continuous gum work lends itself to the most perfect repair of any artificial denture. It must be first burned out, that is, scrubbed with soap and water, invested completely in the silica-asbestos compound, heated up gradually to a high red heat so as to remove all organic matter; when new material may be added and fused securely to the old.

A broken tooth may be repaired by building up with any of the high fusing enamels used in inlay work, or by grinding out the remains of the tooth, setting in either a continuous gum or vulcanite tooth packed with body and baked; gum enamelled and baked. At all bakings the same attention (as described) should be given to heating and tempering (cooling) the porcelain.

Cracks are repaired by placing on a cast, chipping off the porcelain about the crevice, then fill and bake.

CHAPTER XIV

INTERDENTAL SPLINTS

An interdental splint is an appliance made of either metal or vulcanite and placed between the jaws to support a fracture of either or both the maxillæ and mandible.

Interdental splints in conjunction with submental compressors and occipitomental bandages have been used by surgeons in the treatment of fractured jaws since 1780.

Drs. F. B. Gunning, of New York, and J. B. Bean, of Atlanta, Ga., were the first to describe methods of constructing interdental splints of vulcanite.

When a dentist is called upon to construct an interdental splint it will be in consultation with a surgeon. He should, in justice to himself, make a critical examination of the case and determine if an interdental splint is indicated or if some other method will better serve the patient. If the fracture is of the maxillæ only, and the teeth are nearly all *in situ*, it is quite probable that forcing the fractured portions into place and holding the lower teeth firmly against them with a cotton padded external plaster splint and bandage is the preferable method of treatment. Fracture of the mandible *may be* best treated by binding the teeth of the mandible to those of the maxillæ with bands and wires designed for orthodontia purposes, in conjunction with an external plaster compress and bandage. If the patient is wearing a full upper and lower artificial denture, the dentures may be securely united with vulcanite, the upper incisors removed for a feeding space, and used for the splint. However, if an interdental splint is determined upon it should be constructed as recently described by Dr. George B. Snow, of Buffalo.

THE CONSTRUCTION OF INTERDENTAL SPLINTS

Interdental Splint.—"An interdental splint, when properly constructed, forms an efficient and satisfactory means for treating fracture of the mandible, and the Snow face bow and New Century or Gritman antagonizor are absolutely necessary for the attainment of the correct alignment of their occluding surfaces. For this reason a short description of the correct method for this construction is appended.

"These instructions apply to the construction of the 'Gunning' splint. This separates the jaws and receives both the upper and lower teeth. It is retained by means of bandages, and fixes the mandible immovably. It has a wide range of application, and is the most satisfactory splint for general use. The *Snow face bow* is absolutely necessary for its construction, as the casts must be placed in the antagonizor at the same distance from its joints that the alveolar ridges are from the condyles, or the bite cannot be opened for the reception of the splint with any certainty of having correct occlusion when the fracture has united. The fact that the Snow face bow has not been used is the common cause of failure in interdental splints, as they have heretofore been constructed.

"Impressions of the teeth, both upper and lower, are first to be secured. These are better made in plaster, rather than modelling compound, for the plaster is more easily managed and is less subject to distortion. Very shallow impression trays should be used, the *B* mouthpiece of the face bow answering the purpose, and only plaster enough used to obtain an impression of the teeth to the gum line. No attempt need be made to correct any deformity which may be present, and the operation, if properly conducted, will be almost painless to the patient. The impression must take in *all the teeth present* in the mouth, for if the third molars are not included, they will not be covered by the splint, and will elongate while it is in use, and so interfere with occlusion. Fill the palatal portion of the upper impres-

sion with sheet wax or paper just above the gingival line and run a *thin cast*. Run a thin horseshoe cast in the lower impression. With a Swiss saw cut this cast at the point of fracture, and adjust the parts so that they make correct occlusion with the teeth on the upper cast. Secure the two casts together with a *very little* sticky wax. Run a little plaster on a piece of paper and set the lower cast into it, to hold its parts in their correct relation.

"After taking the impressions, place a little soft wax in the *B* mouthpiece and use the face bow as heretofore directed. Place the upper cast in the antagonizor by means of the face bow, and it will be at the correct distance from the antagonizor joints, and when the lower cast is antagonized, their separation to accommodate the splint can be safely made, and normal occlusion secured when the fracture has united.

"Cover the teeth with No. 60 tinfoil, letting the tin extend beyond the teeth, buccally and lingually, and cutting the tin so that it can be put on without crumpling. Follow with one thickness of sheet wax, covering the teeth, both upper and lower, to the gum line. Separate the two wax plates (open the bite), so that a lead pencil will pass between them in front. Connect them at the sides with wax, leaving an opening in front extending from cuspid to cuspid.

"A No. 3 Snow flask (or a box flask) will receive both casts and splint. Set one cast, the splint being in place, the plaster covering the edge of the wax, both buccally and lingually. Trim and soap not only the usual parting surfaces of the invested cast, but the splint and palatal surface of the other cast as well. Holding the loose cast upon the splint, run plaster into the space between the two casts, and build it up around the sides and rear to the edge of the wax. Trim to an incline to the edges of the flask all around. Soap. Place on ring and fill. When separating the flask have it warm enough to soften without melting the wax. Rap the edge of the flask to dislodge the centrepiece. Remove and save the wax, and find quantity of rubber required by immersing the wax in a glass of water. Pack and vulcanize. The tinfoil being left upon the casts, the impression of the

teeth in the splint will be smooth, and also larger than the teeth themselves by the thickness of the foil used. This is why the use of thick foil is directed, as the additional space gained by it renders the splint more easy of adjustment."

Fig. 329

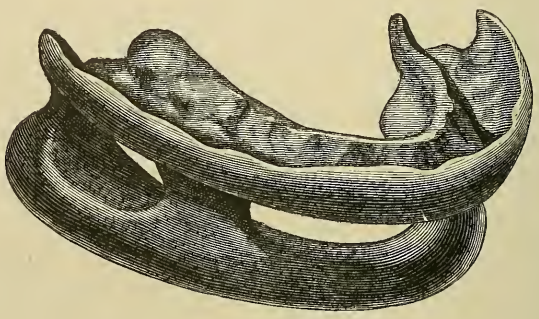


Fig. 330

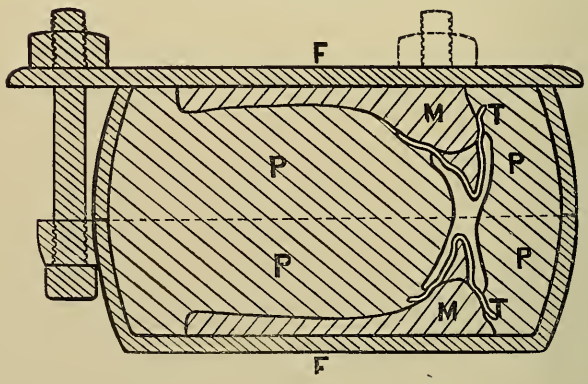


Fig. 329 represents both the wax model splint and the finished vulcanite. Fig. 330 is a diagram showing a cross-section of the flasked case. The flask is designated by *F*, the casts, *M;* the plaster encasement by *P*, tinfoil covering the

teeth with extension beyond the wax splint by *T*, and the wax model of splint in the centre.

Fig. 331 illustrates a splint provided with arms of steel wire, one-eighth of an inch in diameter, arranged to come "out of the mouth when the splint is in position, passing back along the cheek on a line with the teeth." This splint was invented by Dr. Norman W. Kingsley, and the description of it is from his valuable work on *Oral Deformities.* The splint is retained in position by the submental compress attached to the side bars.

Fig. 331

"It will be seen that this splint covers the lower teeth only, and that its top occludes with the upper teeth to admit of mastication. The construction of such a splint is accomplished by placing upper and lower casts in an antagonizor, forming the wax splint as before described, arranging the occlusion so that the contact of the upper teeth will be uniform, embedding two stout steel wires with flattened ends in the wax, so that they will bear the strain which will be required of them while the splint is in position. The particular flask best adapted for the vulcanizing of interdental splints is oblong in form, and is larger than ordinary vulcanite flasks; it is known as the box flask."

CHAPTER XV

CLEFT PALATE APPLIANCES

By cleft palate is meant a defective condition of the roof of the mouth, forming an abnormal opening between the oral and nasal cavities. The cleft may be of the form of a fissure or of a rounded hole. The cleft may be either congenital or acquired. The congenital cleft is due to defective fetal development, but not accounted for. The acquired cleft may be due to either accident or disease. The extent of the cleft may be from a slight cleft of the uvula to one extending through the soft and hard palates and the alveolar process; also may extend through the lip (harelip). If there is no harelip complication, the defect is noticeable only in speech, in which there is an unmistakable nasal intonation. The defect is amenable to both surgical and mechanical treatment, the latter of which only is considered in this chapter.

Apparatus.—There are two types of apparatus for restoring the defects of the roof of the mouth, known as *obturator* and *velum*. Of these, Dr. N. W. Kingsley says: "An obturator is a stopper, plug, or cover, hard, non-elastic, and stationary, fitting to an opening with a well-defined border and shutting of the passage. Such instruments are applicable to perforations of the hard or soft palate resulting from accidents or disease, but they are rarely applicable to a congenital fissure of the velum. An artificial velum is not a temporary stopper, but an elastic, movable valve under the control of the surrounding adjacent muscles, closing or opening the passage at will, and is applicable to congenital fissures, occasionally where the soft palate has been destroyed, but never to perforations of either the hard or soft palate."

Dr. Kingsley further says: "In most cases of congenital

defects, the patient will acquire correct articulation more easily and more certainly with an elastic velum scientifically adjusted than with any other form of appliance, because it more nearly resembles the action of the normal palate and will more readily fulfil its function.

"That in a great majority of cases of a like defect a patient will never acquire distinct articulation with an obturator.

"That where a patient afflicted with a congenital absence of the palate has overcome the difficulty by using an artificial velum until clear and distinct articulation has been acquired, he may change the velum for an obturator, and continue to articulate properly.

FIG. 332

"That of all obturators to supply deficiencies of the soft palate and induce correct articulation, the one introduced by Suersen contains the truest principles and is best adapted to the purpose."

Fig. 332 gives a view of a patient's mouth, showing part of the cleft palate and the appearance of the lip after being operated upon for a harelip.

Fig. 333 is an illustration of a congenital cleft extending through the soft and hard palate and also the alveolar process.

Fig. 333

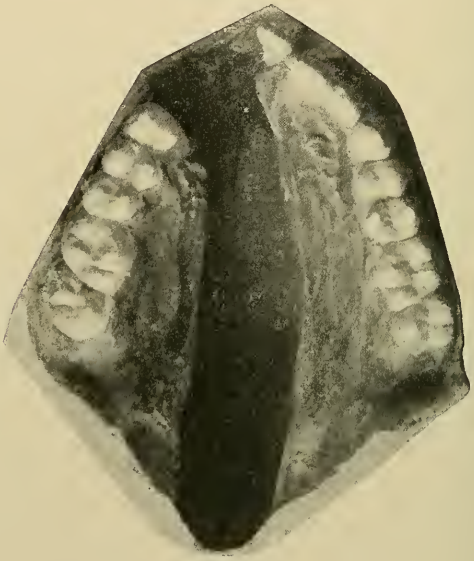


Fig. 334

Fig. 334 shows a cleft of the soft and hard palate, and alveolar process depressed, but not cleft.

Fig. 335 shows a cleft of the soft palate only.

The artificial velum should rarely extend into that portion of the cleft extending through the alveolar process, which may better be filled with the hard vulcanite.

Fig. 335

Synopsis of Technique for Constructing Velum and Supporting Base-plate.—Impression for velum, cast, preparation of cast for making model of velum, making model velum, adjusting model velum to mouth, flasking model velum, converting plaster encasement into metal encasement, vulcanizing velum, finishing velum, impression with the velum *in situ* for the retaining base-plate, constructing the retaining base-plate, and attaching the velum.

Impression of the Cleft.—An ordinary impression tray will not suffice for a congenital cleft palate. A spoon with the convex surface of the bowl upward well serves for a tray to carry the plaster, or one of the two methods described by Dr. C. S. Case, of Chicago. He uses the index finger with soft modelling compound wrapped about it as the foundation for his impression. Having obtained an imprint of the cleft

in the compound, it is chilled and carved so that it may be held in the cleft without contact with the tissues. It is then

Fig. 336

Fig. 337

covered with a soft mix of impression plaster, carefully adjusted, and held until set; then removed by forcing it backward until relieved of the anterior margin of the cleft.

Fig. 336 shows the completed impression as taken from the mouth for a cleft of the soft palate only. The impression is

FIG. 338

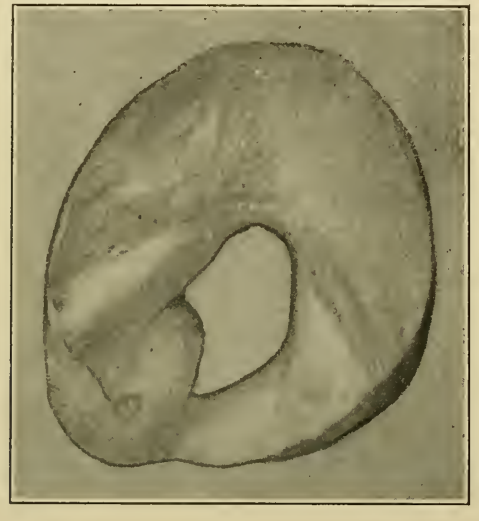


FIG. 339

varnished and filled, as shown in Fig. 337. Fig. 338 shows the cast after removal of the impression. Fig. 339 shows

Fig. 340

Fig. 341

Fig. 342

the cast carved for use. Fig 340 shows the cleft filled with modelling compound carved to thin edges as a model for the

Fig. 343

Fig. 344

velum. Fig. 341 shows the nasal surface of the same. Fig. 342 shows a side elevation of the model velum. Fig. 343

Fig. 345

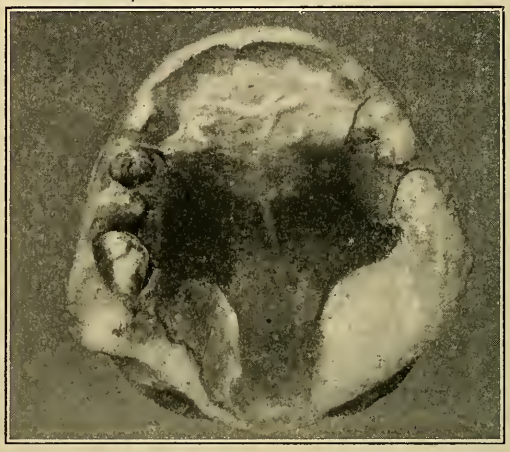


Fig. 346

Fig. 347

shows the finished velum in the plaster cast. Fig. 344 shows the skeleton base-plate upon the plaster cast. Fig. 345 shows the wax model base-plate. Fig. 346 shows a side elevation of the finished base-plate. Fig. 347 shows a side elevation of combined base-plate and velum. Fig. 348 is the lingual surface of the same.

Most of the steps are comprehensible from the illustrations; however, there are several that are not and need elaboration.

FIG. 348

Velum Model.—The velum model is the first step after the impression that needs further consideration. Softened modelling compound is shaped in the carved cast by the thumb and finger. The anterior or body portion of the velum is left thick for a body, while the posterior or curtain portion and the flanges are made very thin with attenuated edges. This is accomplished, so far as possible, by molding the softened material with the fingers, after which it is further reduced with a vulcanite scraper and sandpaper. It is finished with a cloth wet with a solvent, as chloroform or alcohol.

Adjusting Model Velum to the Mouth.—A hole to admit a 14-gauged wire is drilled through the body of the velum model from the oral to the nasal side. A wire with $\frac{1}{4}$ inch of one end bent at right angle is fitted to the drill hole in model; the other end of the wire is looped to form a handle. This wire is used to handle the model while adjusting it to the cleft. The body of the model should be kept hard, but the curtain and flanges may be softened as required by dipping in warm water. It is adjusted by the patient swallowing, trimming away excessive material, and molding with the finger. Additions may be made by tracing on with a pencil of modelling compound. The velum must be so formed that in the act of swallowing it will entirely close the opening between the oral and nasal cavities. The desired form and adaptation being obtained, it is chilled and made smooth. It is then ready for flasking.

Fig. 349

Flasking the Model Velum.—A small sized bolted vulcanite flask is used. The inner surface of the flask is smoothed of any roughness by grinding, and smeared with vaseline so that the encasing plaster may be easily removed. The model must be so encased in the flask that the sections of the encasement plaster may be removed, molded, and

reproduced in metal. This will require three sections of the encasement plaster. Each piece of the encasement plaster is flasked in a suitable flask (box) with silica investment compound and reproduced either in Babbitt or type metal. The operation is simple, but judgment must be exercised both in flasking the velum model and the sections of the plaster encasement. Fig. 349 shows the three sectiosn of the Babbitt metal castings. Fig. 350 shows the bottom and middle castings assembled in one-half of the flask and the third section in the other half of the flask. Fig. 351 shows the box flask with one section of the plaster encasement embedded. Fig. 352 is the same with the plaster model lifted out, forming the mold for casting.

Fig. 350

The encasement in the box flask must be heated to dry it of all moisture so that steam will not be formed in filling with the molten metal.

The surfaces of the castings, which are to give form to the artificial velum, must be carefully polished and burnished, as they should produce a finished surface upon the velum.

A hole must be drilled in both the upper and lower sections of the castings to carry a wire former for the hole in the body of the velum to admit the coupling standard, as seen in Fig. 350. One end of the wire is cemented into the casting, the other end of the wire enters the hole in the other section of the casting, but is not fastened.

Fig. 351

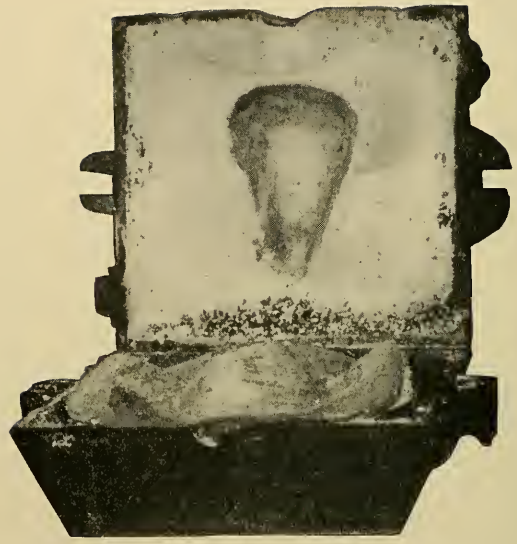
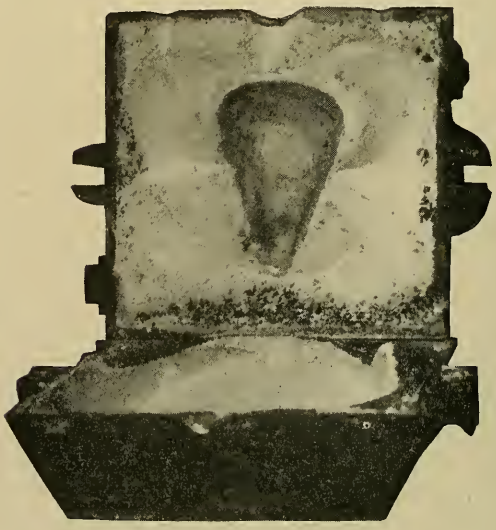


Fig. 352



The wire former should be one or two sizes smaller than the coupler wire.

The surfaces of the metal mold must be soaped and dried each time it is to be used. This is to prevent the velum vulcanite adhering too closely.

Packing Velum Rubber.—The metal mold should be as warm as the fingers can be held upon without discomfort. It is packed, without enmeshing air, with velum rubber (caoutchouc, 25; sulphur, 5 parts), and vulcanized at 300° F. for three hours. The packing should be carefully done, so as to have as little excess as possible, which will force its way out of the metal encasement.

Finishing the Edges of the Velum.—This can be done only by trimming with sharp scissors, searing with a hot iron, and rubbing with chloroform.

Impression for the Retaining Base-plate.—It is necessary that the artificial velum should be held accurately in place while taking the impression for the retaining base-plate. The surface covered by the impression must include the thick body portion of the velum, the vault portion upon which the supporting base-plate is to rest, and the teeth to which the base-plate is to be clasped. The velum is supported by means of a 13-gauged soft iron wire. The end of the wire is engaged in the coupler hole and its shaft conformed to the vault and about the buccal surface of the teeth, and then protrude from the mouth, the external end being looped for a handle. The object is to so bend and shape the wire that it will support the artificial velum, and that no part of it, except the portion near the cleft, shall be engaged in the impression. The selected tray is adjusted. Should the palatal portion not extend sufficiently backward, it should be extended by an addition of wax or modelling compound. The impression is then taken in plaster. The impression with the artificial velum in place is varnished and poured with silica investment compound. Upon this cast the clasps are shaped and the clasp gold wire skeleton is formed. The joining of the various pieces of metal are covered with wax, and the rest of the wire is

covered with investment compound, leaving the waxed joints wide open. The cast about the velum is cut away and the velum removed from the coupler wire. Investment is added to the exposed end of coupler wire. The case is heated and soldered. The skeleton frame with velum

Fig. 353

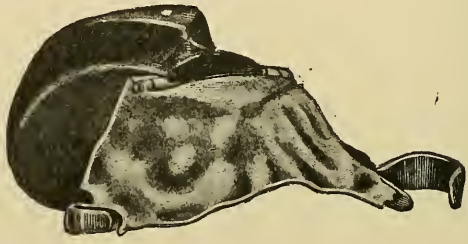


Fig. 354

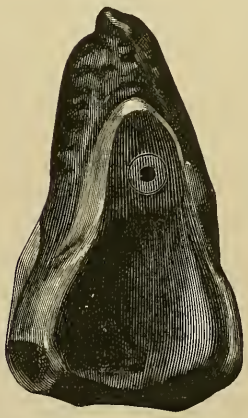


Fig. 355

attached is adjusted to the mouth and impression taken for the vulcanite base-plate. The impression should extend at least $\frac{3}{8}$ of an inch back of the coupler pin. The impression will probably be much broken in removing from the mouth; the impression and metal skeleton are assembled without the

velum and the impression varnished and poured with plaster (Fig. 344).

If a gold base-plate is desired, the first impression with the artificial velum in place is poured with plaster (in place of investment compound), a die and counter formed, the gold base-plate constructed, and the coupler pin attached with solder.

Fig. 356

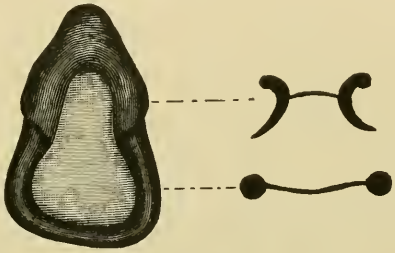
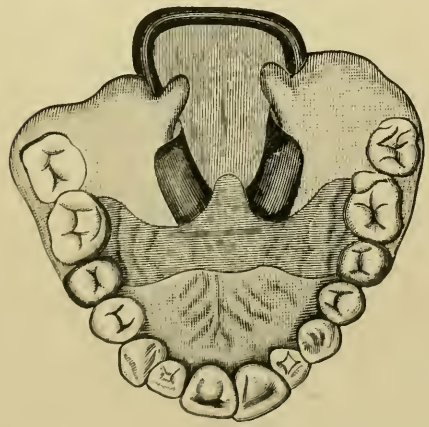


Fig. 357



Suersen Obturator.—This obturator is a hard vulcanite hollow bulb made to fill the cleft, and upon which the divided palate glides while speaking and swallowing. The principal merit of this apparatus is that it is cleanly and

durable. Reference has been made to Dr. Kingsley's statement as to its usefulness. Figs. 353, 354, and 355 illustrate

Fig. 358

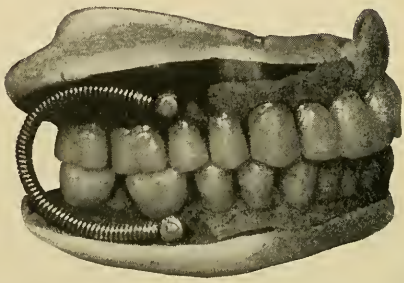
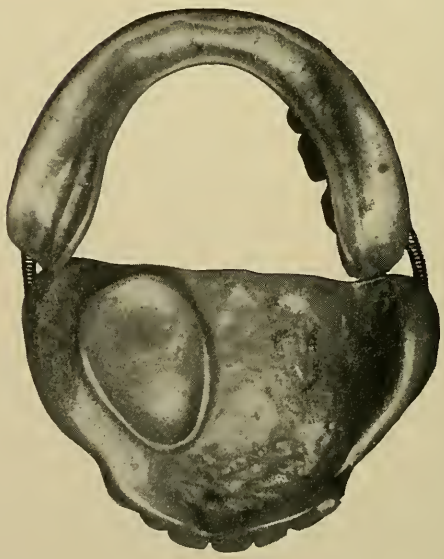


Fig. 359



three Suersen bulbs (obturators), one of which is attached to a base-plate retainer.

Velum Obturator.—The latest invention for the relief of this distressing deformity is Dr. Case's velum obturator. This instrument consists of a peripheral roll and an intervening septum of velum vulcanite. Figs. 356 and 357 illustrate this apparatus. A full detailed description of the apparatus is to be found in Dr. Case's book.

Denture Obturator.—Figs. 358 and 359 show two views of a cast aluminum denture obturator made necessary from a surgical operation for the removal of a tumor of the maxillary sinus.

Reference Books.—Kingsley's *Oral Deformities*, *American System of Dentistry*, *American Text-book of Prosthetic Dentistry*, and Case's *Orthopedic Dentistry*.

CHAPTER XVI

ESTHETICS

For the purpose of establishing a clear idea of what we mean by "esthetics of prosthesis," we define the term "prosthesis" as: The science, art, and esthetics of restoring a lost dental organ or organs and associate parts with an artificial substitute.

To understand this subject, we must have well-conceived ideas of the three terms, science, art, and esthetics. Science is classified knowledge; therefore, it is the involved theory. Art is a complex term; primarily, it means doing a thing in a skilful manner; thus, it is used to express perfection in any oft-repeated mechanical work, as the manual labor in any of the useful trades, useful arts and crafts; and to the working out of beautiful thoughts in concrete form, fine arts. As esthetics expresses the latter idea, we incorporate in our definition the two terms, *art* and *esthetics*. Art, to express the skilful doing of mechanical work, and esthetics, to express the harmonizing of our creation with its environment, or, the art of concealing art. Thus, when we mean the skilful construction of mechanical appliances, we shall speak of art, artistic, and artisan; but when we mean that which is more than mechanical art, the ideal, the beautiful, because harmonious, then we shall speak of the esthetic and esthetist or artist.

Is prosthetic dentistry a trade or a profession? That depends entirely upon how it is practised. The science involved is not a factor in determining whether prosthesis as practised is a trade or a profession; for both the useful and fine arts may be highly scientific. If prosthesis is practised as a utilitarian art, then it is, and can only be, a trade: but if the utilitarian art is dominated by esthetics,

then and only then can it justly be called a profession. The *Standard Dictionary* defines a profession as: "An occupation that properly involves a liberal education or its equivalent, and mental rather than manual labor." Hunter's *Encyclopedic Dictionary* defines a profession as: "A business which one professes to understand and to practise for subsistence; a calling, occupation, or vocation, superior to a trade or handicraft." Is it not conclusive that a commercial dental laboratory is practising "mechanical dentistry" only? In order to practise prosthesis (Greek, *pros*, to; *tithemi*, place, to place or restore) it is necessary that the patient shall be under the inspection and study of the prosthetist so as to restore the contour and harmonize the associated parts. If one is to practise prosthesis as a profession, he must be more than an artisan; he must be an artist. It is a common saying that artists are born and not made. This saying, like most of its kind, is only in part true. However, we can say there are but two sources from which artists may be produced, namely, made and born, cultivation and intuition. The idea of an artist being cultivated is in keeping with the Standard Dictionary definition of a profession, that is: "A liberal education or its equivalent, and mental rather than manual labor." The artist must have, in addition to the manual dexterity of the artisan, the developed mentality and imagination that can create ideas and ideals, and then, with his artisan dexterity, he puts his ideals into concrete form. Thus, he makes of his useful art a fine art; and he becomes an esthetist, an artist, and his calling is a profession. Therefore, if one would be an esthetic prosthetist, he must develop himself and broaden his art. The remaining source from which artists are produced, that is, born, or, as we classified the idea—intuition—is an unknown quantity and of uncertain value. However, for a dentist to depend upon intuition for producing esthetic work would be like a preacher depending upon inspiration for his sermon; too often the product would only be perspiration. True it is that some people seem to have more natural ability than others; but it is more than probable that much of this seeming

inherent or intuitive ability is the result of early cultivation in ways that have contributed to the final product.

There are two attributes of a man that are necessary for success in any line, namely, desire and energy. Desire and energy is the celestial fire which will, when sufficiently strong, accomplish everything. Longfellow has well expressed the thought in this stanza:

> "All the means of action—
> The shapeless masses, the materials—
> Lie everywhere about us. What we need
> Is the celestial fire to change the flint
> Into transparent crystals, bright and clear.
> That fire is genius."

Someone has said that "Genius is infinite capacity for painstaking." Thus, we must conclude that if a dentist does not succeed in reaching high attainments, the celestial fire within him is passive and not active; or, that his energies have not been well directed.

Thus far we have endeavored to establish what is esthetics of prosthesis, and present the conclusion that it is applied, refined ideals of prosthesis, developed by earnest desire and well-directed energy.

Dr. Charles Channing Allen has well expressed the relation of esthetics to dentistry in a paper read before the Kansas State Dental Association, May, 1908:

"When a work is executed with the concepts of beauty, utility, and economy in their proper proportions, that work has its own individual characteristic, the evidence of design. This is its passport; its credential; its hall mark; its justification. In such character it shows whether it is the legitimate child of orderly intelligence, or the bastard of bungling incompetency. If it was fathered by an understanding of the requirements and a skill sufficient for their execution, then it must appeal to the mind as answering the requirement of esthetics—the beautiful. . . . Although in giving consideration to design over mere beauty we cannot accept the dictum that beauty is without definite utility. Beauty carries with it more of the evidence of design than

mere utility, for the esthetic or beautiful appeals to one immediately, and does not require a systematic proof along the recognized lines of logic, but establishes itself in the mind of the beholder at once without proof. Utility alone, as an ultimate end, executed without embellishment, may be, and usually is, vague in expressing its reason for existence, and must be studied and its purpose analyzed, often laboriously at tiresome length.

"No profession has more use for the esthetic and beautiful than the profession of dentistry; for an esthetic restoration is a very important part of our obligation to our patient."

We assume that the Creator designed that every soul should inhabit a perfect body. According to its type, it should be like the Greek creation Apollo, every line and every inch god-like in its perfection. Had the original design prevailed, there could have been no beauty associated with the human form, because there would have been but one type, and each individual would have been a duplicate of all others. Beauty is appreciated by contrast only. The Creator also gave the laws of environment. Therefore, we have not two persons that are exact duplicates of each other. As the body is molded and shaped by external mental and physical influences through conception and gestation, and by both external and internal mental and physical influences through infancy, youth, adult, and senility, there can be no perfect duplicate or absolute conformity to a given standard; and yet, how wonderfully alike are human beings!

Ethnologists, physiognomists, and other scientists have divided and subdivided the human family into many classes for the purpose of better studying man. So far as prosthetists are concerned, our studies have been confined almost entirely to the Caucasian race, and we consider only such classification as will aid us in understanding the needs of the profession. We first divide the race into classes—light (blond) and dark (brunette)—a simple classification easily understood, and which call attention to certain facts. The next classification is into "temperaments," dividing the race

into three, four, or five classes, according to the classification chosen. These divisions, with their various combinations, will carry us much farther into the physiognomical study of our patients; will establish types, and teach us to note the variations in each subject from the type.

Another classification we may call the "dental profile" classification. Scientists consider this subject as a study of the facial angle, and make two general divisions—orthognathous and prognathous. This division is of little value to the dentist, yet the study of the profile is perhaps the most important of all the classifications for the prosthetist.

DENTAL PROFILE

For convenience, we divide the dental profile into three classes—*straight* profile, *convex* profile, and *concave* profile.

Scientists in drawing the perpendicular line of the face have it touch the most prominent point in the median line of the forehead and the most advanced portion of the maxillæ. The dental profile line is somewhat different from the perpendicular facial angle line.

The first class, or straight profile, is the ideal Greek face. The perpendicular line has three points of contact—the frontal and mental eminence, and the middle of the wing of the nose. The lower lip will just touch the perpendicular line, and the upper lip will be a little in advance of the line. There is no question that this is the normal profile of the highest ideal of beauty.

The second class, or convex profile, has two points of contact with the perpendicular line—the frontal eminence and a point at the base of the nose which is the same distance from the middle of the back of the ear as the frontal eminence. In the type, this point will be the centre of the wing of the nose.

The ideal standard of this class has the face made up of rounded, graceful curves; forehead high and slightly receding; nose of Greek or Roman type; lips full but not coarse; chin

receding but not weak; teeth, both number and alignment normal. No competent orthodontist would think of converting this ideal of our second class into the first or straight class, for he would recognize that the harmony of the features would be destroyed.

The third class, or concave profile, has the frontal and mental eminence only in contact with the perpendicular line. It is not possible to conceive of this profile being a mark of beauty, and it is fortunate that the class is small compared with the other two. It is a condition confronting the prosthetist, and he must place the features in as pleasing a relation to the concave line of the individual as possible.

The physiognomy of man is gradually changing and tending toward types. The intermarriage of different nationalities and the modes of living, causing mental development and physical degeneracy, partly account for this condition. For the last few years, orthodontists have been impressing upon our attention the importance of teeth in the physiognomy of man, and giving us a rational reason for many of the abnormal conditions. This same study is of value to the prosthetist, as it aids him to understand the design of nature for the individual case; also aids him in classification. In studying the harmonies and inharmonies of the face, it is important that we consider the causes as well as the effects.

When the prosthetist has studied the individual case and classified it, he is confronted with the question: What is one's duty, to restore the features to the natural or to the normal condition? It is apparent that a normal convex profile should not, in a portion of its outline, be converted into the concave type, thus forming an ogee monstrosity. Each individual case must be kept within its normal class, then it is a matter of judgment for the prosthetist and patient to decide to what extent the natural peculiarities shall be modified.

It should be borne in mind that physiognomists make a distinction between anatomy and expression. Expression is of the soul, by and through the anatomy. Therefore,

deformities of the anatomy may belie the soul. The prosthetist should study well to have the teeth of the proper size, color, form, arrangement, and the dentures so contoured that they may harmonize with the rest of the anatomy of the face. The esthetics of prosthesis may be expressed thus: Harmonious in anatomy and pleasing in expression.

HARMONY

The preceding chapters of this book have been devoted to developing the mechanical phases of prosthesis, also a reasonable science for the modes of procedure, and, incidentally, the cosmetics have been touched upon. However, in teaching the science and art of prosthesis it is not wise to more than intimate the existence of the esthetic, because of the confusion and distraction of mind created. The prosthetist must first become an artisan, and then, with patient endeavor, develop the artist. The utilitarian art is the first consideration, and is that for which there is the greatest demand; but for the mechanical dentist to dignify his work and make himself worthy to be ranked as a professional man, he must place the stamp of ideality upon the product of his hand. As there are no two individuals exactly alike, in fact no individual, one side of whose face is the counterpart of the other, it is impossible to establish fast rules for esthetics. It is possible, however, and is the province of this chapter to map out certain lines of thought, and some technique as a means for harmonizing the work of the craftsman with the environment and making pleasing the expression of the individual. To recapitulate: The finishing touches of the artist shall conceal the work of the artisan. As the sculptor and painter may only express their thoughts in tangible substance, so it is that the dental esthetist may only express his thoughts by means of the artificial denture. The value, therefore, of the prosthetist's creation is not in the intrinsic value of the physical material entering into it, but in the quality and quantity of thought expressed in the artificial substitute. The science and art of prosthesis

deals with the materials and manipulation of them, whereas esthetics has to do with contour and color regardless of the material used. Contour and color are concerned with the surface only, therefore the lingual, labial, and buccal surfaces are the subjects for our further consideration of artificial dentures.

Lingual Surface.—The lingual surface of the maxillæ is dome-shape, but varies in conformation from an inverted V to a flat surface. As the dome of the mouth is one of the resonant chambers, useful in articulate speech, it is evident that its form has much influence in sound formation. This does not imply that a definite shape of the vault is necessary to articulation, but it does imply that certain conformations are more favorable for clear enunciation than others, and that clear enunciation cannot be had with every vault formation. Therefore, the prosthetist may mar or improve the conditions for good enunciation. The rounded oval dome vault is the best devised for human speech. However, the genius of mankind is great, and he can overcome many of the impediments to sound formation. Nevertheless, when he has acquired the art of enunciation, any radical change in this resonant chamber will necessitate a change in the manner in which the tongue is conformed and placed. Therefore, it is logical to assume that the conformation of the lingual surface of the artificial denture should be as near the size and conformation of the vault in which the subject has acquired good enunciation as possible; otherwise the individual will have to learn the art of clear speech over again. Chapter I, in connection with Figs. 12, 13, and 14, illustrate the changes that take place due to the loss of the teeth. Fig. 12 demonstrates that any unnecessary thickness of the lingual surface of the denture is an impediment to speech; however, as a mechanical appliance is essential to restore the lost tissues, good mechanics requires that the apparatus shall have a safe margin of resistance to the stress to which it may be subjected. This will require a thickness of material in the indirect ratio to the strength, rigidity, and elasticity of the material employed. Is it not evident

that the carving of the lingual contour of the teeth, gums, and rugæ, as seen in many of the illustrations of this book, are more than fanciful, that it is the acme of the practical in restoring enunciation? Further than this, the restoring of the rugæ is beneficial as an aid to the tongue in deglutition. Chapter I should be read as a further elucidation of this theme. The technique of restoring the lingual surface consists of the methods previously described and illustrated. The requirements of esthetics are that the original contour of the lingual surface of the maxillæ shall be reproduced as nearly as possible; that excessive thickness of the linguocervical portion should be employed only when other conditions make them imperative.

Labial Surface.—The labial surface may be defined as that depicted by the incisor and cuspid teeth. The contour of this surface of the artificial dentures is to give support and form to the overlying soft tissues, thus restoring the anatomical harmony and aiding in the expression. There are two portions of this surface to be considered, namely, the gum portion and the teeth. Chapter I describes the change wrought by resorption of the alveolar processes, and the same chapter explains the muscles and their action associated with this surface of an artificial denture.

The contour of the gum portion requires that it shall not impinge upon the frenum labii, nor make too full the incisal fossæ; but that it shall restore the cuspid eminences, including the nasobuccolabial triangles. As previously suggested, the contour for the individual case will be determined by the temperamental condition. The contour of the teeth will be influenced by the temperament and age of the patient. In order to understand the temperamental influences, it is necessary to digress from the theme of study and consider abstractly the temperaments.

TEMPERAMENTS

Dr. Jacques defines temperament as: A state of the body depending upon certain combinations of the various

systems and organs and certain functional conditions affecting them.

The temperaments are physiological conditions and are usually considered unchangeable. Dr. Jacques, than whom there is probably no greater authority, states, on page 110 of his book, *The Temperaments,* that:

"When once established, the temperament inclines naturally to perpetuate and increase itself, since it gives rise to habits that exercise the organs on which it depends. A change of temperament, then, implies strong counteracting influences brought to bear upon the constitution; and as such strong influences are in a majority of cases lacking, the inherited tendency is generally followed, and a temperament once established is maintained through life. This, however, is far from being universally the case. The inherent predisposition is sometimes entirely overcome and the constitution radically changed."

There are various classifications of the temperaments; but the one here used (because it is the one associated with the classification of teeth) is the one apparently adopted, and described by Dr. Spurzheim.

"1. **The Lymphatic Temperament.**—The lymphatic or phlegmatic temperament is indicated by pale white skin, fair hair, roundness of form, and repletion of the cellular tissue. The flesh is soft, the vital actions are languid, the pulse is feeble; all indicate slowness and weakness in the vegetative, affective, and intellectual functions.

"2. **The Sanguine Temperament.**—The sanguine temperament is proclaimed by a tolerable consistency of flesh, moderate plumpness of parts, light or chestnut hair, blue eyes, great activity of the arterial system, a strong, full, and frequent pulse, and an animated countenance. Persons thus constituted are easily affected by external impressions, and possess greater energy than those of the former temperament.

"3. **The Bilious Temperament.**—The bilious temperament is characterized by black hair, a dark, yellowish, or brown skin, black eyes; moderately full, but firm muscles, and

harshly expressed forms. Those endowed with this constitution have a strongly marked and decided expression of countenance; they manifest great general activity and functional energy.

"4. **The Nervous Temperament.**—The external signs of the nervous temperament are fine, thin hair, delicate health, general emaciation, and smallness of the muscles, rapidity in the muscular actions, vivacity in the sensations. The nervous system of individuals so constituted preponderates extremely and they exhibit great nervous sensibility."

These four divisions are spoken of as primary temperaments. It would be exceedingly difficult to find an individual whose organization complied with any one of these divisions only. Most persons show one temperament markedly strong, but modified with one or more of the other temperaments; while others possess an equal blending of two or more temperaments. It is this blending of the classes in varying degrees that causes the difference in the physiognomy of persons and peoples. However, to study the complex it is necessary to reduce it to its components; therefore, the temperaments are first studied in the primary classification, as, lymphatic, sanguine, bilious, and nervous; and then in the binary classification, as, lymphatosanguine, and sanguo-lymphatic, the one being the basic and the other the modifying temperament. Unfortunately, writers are not agreed in the manner of forming the compound noun. Some writers first name the basic and then the modifier, as, sanguo-nervous; others reverse the order, as, nervosanguine, both referring to the same physiognomical condition. Because of this confusion of nomenclature the writer prefers using a phrase in place of the compound noun, as, the sanguine modified with the nervous temperament, or, the nervous modified by the sanguine temperament. The meaning is then unmistakable.

Dr. Jacques states that it is very difficult to get portraits representing the lymphatic temperament, but that the illustrations he gives show its general tendency. Figs. 360 and 361 are reproductions of two of his examples. The one

to the left is modified with the bilious temperament, while the one to the right is modified by the sanguine temperament.

Fig. 360

Fig. 361

Fig. 362

Figs. 362, 363, and 364 are reproductions of his examples of the sanguine, bilious, and nervous temperaments consecutively.

Fig. 363

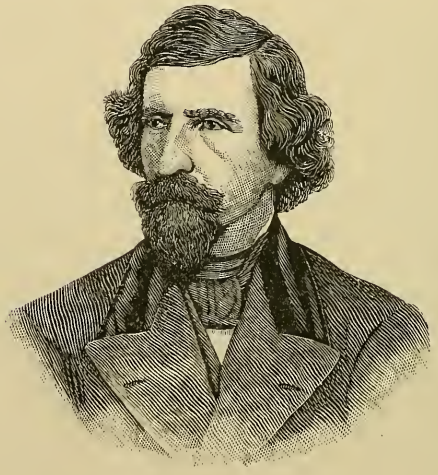
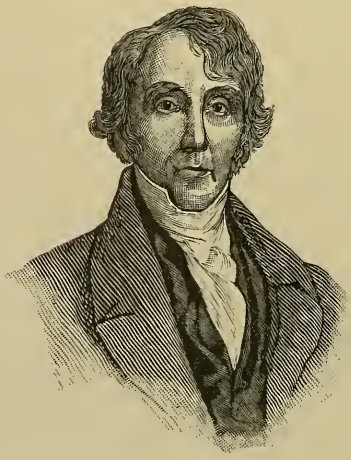


Fig. 364



Professor Prothero, of the Northwestern University Dental School, in his book *Prosthetic Dentistry*, presents a condensed table of the primary temperaments and their appropriate teeth. The table here reproduced will aid in fixing in the mind the main facts pertaining to the temperaments and their application to the selection of teeth for an edentulous patient.

	Basal temperaments.	Eyes.	Hair.	Teeth.	
				Color.	Shape.
Classification of temperaments	Lymphatic	Pale blue or gray	Fine and silky, but without luster	Pallid, opaque, or muddy yellow	Poorly shaped, broad and flat
	Sanguine	Blue, brilliant, and expressive	Blond-red or chestnut, seldom dark or black	Cream-yellow, darker at neck	Well proportioned, curved and rounded
	Nervous	Light gray or blue, restless, often morbidly brilliant	Fine, light, and soft	Pearl-gray, or blue tinge	Long, conical, and rounded
	Bilious	Black or brown, small and piercing	Coarse, dark, often black, and abundant	Strong, bronze yellow	Conical, long and angular

Elaborate descriptions and extensive classifications of the temperaments may be found in both the *American System of Dentistry* and the *American Text-book of Prosthetic Dentistry*. The student is referred to these works for a further investigation of this subject.

APPLICATION

Returning to the theme, *labial surface*, it remains to apply the ideas presented under the headings Profile and Tempera-

ments. This may best be done by use of a patient. The patient (Figs. 365 and 366) has been edentulous for many years. She is about sixty years of age, strongly sanguine, with a nervous temperament modification. The sanguine temperament is indicated by the generally rounded cast of features and physique of the blond type. The nervous temperament is indicated by the width of the forehead and by the toning down of the blond type of coloring.

Figs. 367 and 368 present the patient wearing artificial dentures that do not restore the harmony of the face, therefore causing her to appear more aged than she is. Notice the straight profile, which should be slightly convex, the exaggerated lines about the mouth, the compressed lips, and the depressed nasobuccolabial triangle. Compare this with Figs. 369 and 370, in which the features have been restored so that the lips in profile are slightly protruding, the exposed mucous membrane is natural and in keeping with the thickness of the lips. Observe the gradation from the thin, compressed, severe, and repelling expression of the edentulous mouth, to that of the serious, but cheery and pleasing expression of the restoration. Surely the dentist's handiwork may belie the soul, or it may be in harmony with that of the Creator and Father Time.

Occlusion and Contour Models.—Chapter IV instructs how to form the occlusion models, but necessarily the contouring of the models could not, at that time, be discussed. Now, in the study of the esthetics of restoration, the required contours of the wax models should suggest themselves to the mind of the student, and he should see that a half-hour or even an hour spent in modelling the contour models is time well and profitably spent. Fig. 65 shows the wax models with the median portion and the incisive fossæ depressed, and the cuspid eminence represented. The occlusal border of the upper model overlaps the lower; and the lower model is depressed horizontally to represent the sulcus mentolabialis of the external surface of the lower lip. While the occlusion and contour models represented in Fig. 65 were not for this patient, their conformation is very similar to

Fig. 365

Fig. 366

Fig. 367

Fig. 368

Fig. 369

Fig. 370

that which was required. However, Figs. 227, 228, and 229 are of the denture in the mouth of the patient shown in Figs. 369 and 370.

Technique of Model Contouring.—The wax models, having been constructed for occlusion, are placed in the mouth and, with the face in repose, studied for contour. The face is studied in profile and in full front, while the portion of the

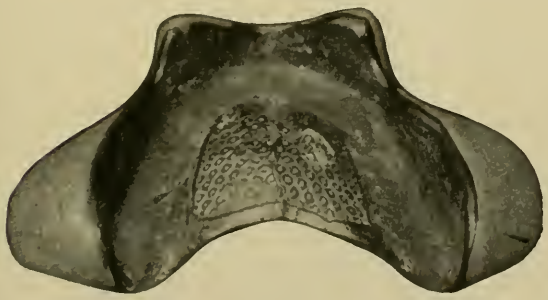
Fig. 371

wax models to be added to or taken from is determined by gentle pressure of the fingers upon the external surface of the lips. While conducting this contour modelling of the labial surface of the wax models, the prosthetist must be certain that the mandible is in retrusion. The anatomy of the parts to be considered in the model restorations are described in Chapter I. It is unnecessary to develop perfection of restoration in the wax models, for the final esthetic

restoration is to be wrought in the model dentures, that is, with the porcelain teeth mounted on wax. Little attention need be given at this time to the linea nasolabialis, nor need the patient be shown the restoration; indeed, it is not well to call attention to this phase of the construction; because the work is only blocked out and a trained imagination is required to comprehend the result, which attribute the average patient does not possess.

FIG. 372

FIG. 373



Buccal Surface.—This surface need not be considered in the occlusion models from the viewpoint of contour, but it needs careful consideration at the time of proving the occlusion and contour of the model dentures. The patient

Fig. 374

Fig. 375

shown in Figs. 369 and 370 requires no buccal restoration, and this is true of probably a majority of patients.

Fig. 371 is a profile view of a patient requiring extensive restoration. Figs. 372 and 373 give two views of the required artificial dentures as first developed in the models and then reproduced in vulcanite. Figs. 374 and 375 give two views of the features restored. The buccal contours do more than reduce the excessive dimples of the cheeks, they modulate the linea nasolabialis, and in such a way that the line is flexible and graceful both in repose and action. If the cuspid fossæ are built out in the artificial denture, for the purpose of obliterating these lines in repose, it will produce an exceedingly disagreeable effect when the mouth is in action.

EXPRESSION IN ACTION

If the face were always in repose the study of esthetics would be finished, but the severest test of the esthetic creation is when the patient is speaking and laughing; for then the size, form, color, arrangement, and individualized effect of the teeth are on exhibition, and if the prosthetist has concealed the art, he is an esthetist, and need not be ashamed of his handiwork.

TEETH

Size.—The size of the teeth were considered in the technique of construction (Chapters I and VI).

Form and Color.—The form and color of the teeth are determined by the temperament when the patient is edentulous, but are selected to harmonize with the remaining teeth in partial cases.

Arrangement.—The teeth are arranged as instructed in Chapter VI, modified slightly so as to conform to the temperamental indications of the patient; that is, the lymphatic type will require the arrangement to be a trifle

flatter and broader than described in the mechanical setting up of the teeth; the sanguine type will require no change in the six anterior teeth, but the bicuspids should be slightly more prominent; the bilious type will require the central incisors to be depressed so as to give a square effect, but no change distal to the cuspids; the nervous type may have the centrals more prominent and the cuspids slightly depressed.

Individualization.—Here no rule can be established, for it is the little touches, here and there, by way of slightly rotating, inclining, protruding, retruding, extruding, or intruding one or more of the teeth; also grinding, inserting fillings, and staining the teeth that completes the harmony. This work should be done by the aid and with the approval of the patient, and possibly a friend. It is often wise to lead the patient or friend so that they will suggest the desired change. However, this does not imply that inartistic and monstrous desires of some patients are to be complied with, not at all, but if the patient can be led to suggest what is really needed, it will usually be more readily accepted. This will prove a good suggestion if properly used. Nevertheless, there are many patients that have little artistic sense, and cannot be asked to aid in this important task. Unfortunately these are the persons who are later subject to the influence of incompetent critics.

Gold Fillings.—Gold fillings may at times be inserted so as to greatly relieve the artificial effect, especially when the patient has had, for years, conspicuously displayed gold fillings. In such cases it is well to reduce the size and number of the fillings and place them so as to give the appearance that the patient has gone to a more esthetic practitioner. Gold crowns for display purposes should never be tolerated unless the patient is markedly "loud" and nothing less would complete the harmony.

Technique.—The tooth to be filled is cupped out with a small stone, so as to form a saucer-shaped cavity; dovetailed grooves may be cut with a small knife-edged disk stone, and retaining pits made with a diamond drill kept

wet with water. The tooth may be mounted with sealing wax on a block of wood, as a means of support while filling with gold. This mounting may be done before preparing the cavity, but preferably after the cavity is cut.

STAINING THE TEETH

The manufacturers of artificial teeth are to be commended for the excellence of their product, but such stock cannot be individualized at the factory. The expert artisans in the factory are most competent to prepare the crude earthy material, grind, compress, and fuse it into blocks having the semblance of teeth, perfect material for the hand of the artist. The error has been made by the profession in that it demanded of the manufacturer a finished product for the individual case, which is an impossibility. The artist, and he is the dentist, must take the product of the artisan and individualize it.

The manufacturer has, for convenience of marketing, arranged his stock of teeth in sets. These sets vary in number from two to twenty-eight teeth, and are of uniform color, that is, the color, tint and shade are the same in each of the teeth; while in nature the tint and shade of a set of teeth vary materially.

Shade and tint are technical terms of the colorist. *Shade* implies that a small amount of black is added to deepen the color, while *tint* is produced by the addition of white.

Dr. E. A. Royce, of Chicago, has called attention to the fact that the upper central incisors are the foundation tint of the teeth in a set, while in the laterals and cuspids the shading is progressive and then diminishes through the first and second bicuspids and first molar. The lower teeth follow the same rule, beginning with the centrals a little darker than the upper centrals.

The amount of shading in each of the classes of teeth will vary with the environment, that is, temperament, age, and the influences of waste and repair. Therefore, for the

manufacturers to attempt to supply, through the trade, teeth esthetically constructed for each individual case would result in a bewildering confusion. The artisans are doing well their part in supplying stock teeth, but the prosthetist must develop the esthetics, otherwise he is an artisan and not an artist. The operative dentist's claim to professional recognition is founded upon pathology; the prosthetist's professional claim is based upon esthetics; consequently he is, or is not, an artist.

Materials for Staining Teeth.—The supply houses of both this country and Europe have placed upon the market the necessary equipment for staining and changing the tint and shade of teeth. This equipment consists of a few colors (either primary or mixed colors), usually a fluid as an applying medium, a mixing spatula, brushes, and a mixing slab of glass or porcelain. As instructions for use accompanying each outfit, it is unnecessary to consider the various kits.

The colors are mineral (metallic oxides) incorporated with a body of the nature of glass (sometimes called porcelain). They all fuse and form a glaze over the surface upon which they are applied. Therefore, to use them to change the color of an artificial tooth to match the color of another as it comes from the factory is not their intended use. They are an over-glaze and not an under-glaze, that is, the color is on the surface, not under the surface. The various materials placed upon the market vary greatly in fusibility and durability. The rule is, and has been, invariably true in the past that the durability is in the inverse order to its fusibility. However, the last claimant for consideration (Lenox mineral stains) may be an exception to the rule. It certainly is exceptional in some respects. As the fusibility of glass and porcelain products has been contingent upon the amount of flux (alkali) incorporated, this new material must be subjected to the test of time to prove its wearing qualities. The writer has tested the Lenox material with the Price pyrometer, and has found that it takes a very good glaze with an exposure of one minute at 1100° F., and that it resists the friction of the felt

wheel and pumice stone. It is better glazed at 1400° to 1500° F. It is surprising that the material stands 2300° of heat almost as well as the White and Brewster colors, which require at least 2000° F. to give them a suitable glaze. The new product is ground exceedingly fine, and in that respect is a superior product. However, until it has been demonstrated that this new material resists perfectly the disintegrating action of the fluids of the mouth, the writer shall place his faith in the higher fusing materials.

Mixing Fluid.—The fluid used has no action upon the paint material, it is only a means for applying and retaining the powdered pigment. Water, gum Arabic water, oils—as cloves, poppy, lavender, and turpentine—also glycerin, are used. Water is the most unsatisfactory fluid named. Of the oils, that of cloves is excellent; its unctuous nature is its only drawback. Glycerin has recently been recommended by Dr. Royce, and it certainly is an excellent medium.

Technique.—The paint or stain is spatulated upon the slab with the chosen medium to the required consistency (thick for deep color, and thin for light tint) and applied to the alcohol cleansed surface of the tooth with a soft pencil brush. It may be more evenly spread with a short stubby brush used as a stippler. Certain effects may be produced by a light wiping stroke of the finger. This will remove the color from the elevated portions and leave it in the depressions and grooves. Highly vitrified teeth may be much improved by spreading the color over the surface with a pencil brush and stippling with the ball of the finger. This produces the columnar crystalline effect of the natural tooth. The painted tooth is dried in a moderately warm place, then glazed at the required temperature.

Suggestions.—The tooth should not be handled with the fingers after cleansing with alcohol, but with clamping pliers attached to the pins.

The tooth or teeth while in the furnace should be placed with the face side upward; the pins, however, should not come in contact with the bottom of the furnace or heating

slab. Place a quantity of finely crushed quartz in the bottom of the furnace, or upon the slab, upon which the teeth may rest, and also as a protection for the pins from too rapid heating, thus avoiding danger of checking the teeth.

To prevent blisters in the paint, heat up slowly. The slab or tray upon which the teeth are heated may be taken from the hot furnace and placed in a cooling muffle.

Coloring.—It should be remembered that there are but two primary colors in the natural teeth, yellow and blue, but many tones (degrees of color) of these colors. The color of the various teeth is produced by shading, tinting, and blending. Therefore, in staining teeth the primary color must be noted and an estimate made of the amount of shading a darker color will produce before producing the characteristic color upon the surface.

It is always easier to deepen the color of a tooth than to make it lighter.

The natural teeth are constantly growing darker with age, just in the ratio to the change in the natural complexion of the patient. This is due to the fact that the teeth belong to the dermal tissue and both are pigmented by the circulating fluids of the body. Therefore, in coloring or staining the teeth they may be shaded a little darker than the natural ones and be less conspicuous.

The natural teeth are subject to many external coloring influences, as smoking and chewing tobacco or other drugs, discolored incipient decay or white or yellow spots from defective calcification of the teeth.

APPLIED ESTHETICS

A few practical cases will suffice to elaborate this phase of the subject.

Figs. 376 and 377 is the patient previously presented, laughing. Fig. 376 shows the gum of the gum section teeth, although much retruded. The teeth are undersize and have the artificial appearance of their type. Fig. 377 shows

Fig. 376

Fig. 377

another view of the contour as illustrated in Figs. 369 and 370 properly restored, and if the teeth are of suitable

Fig. 378

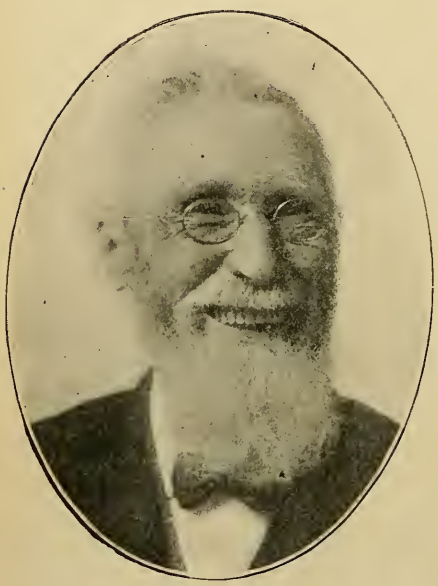


Fig. 379

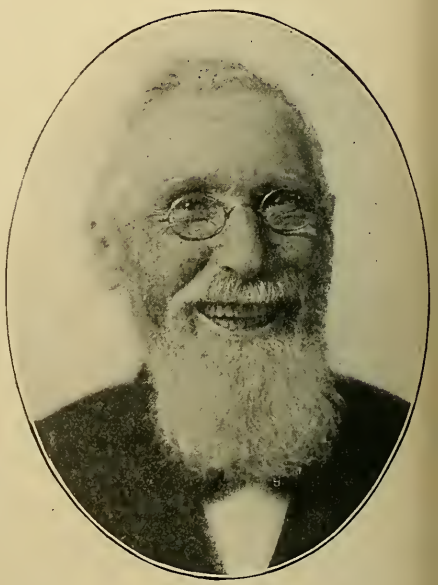
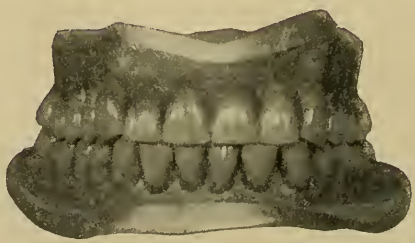


Fig. 380



form, size, color, and individualized, they appear like well-preserved natural teeth. If they do not harmonize in every

FIG. 381

FIG. 382

FIG. 383

FIG. 384

Fig. 385

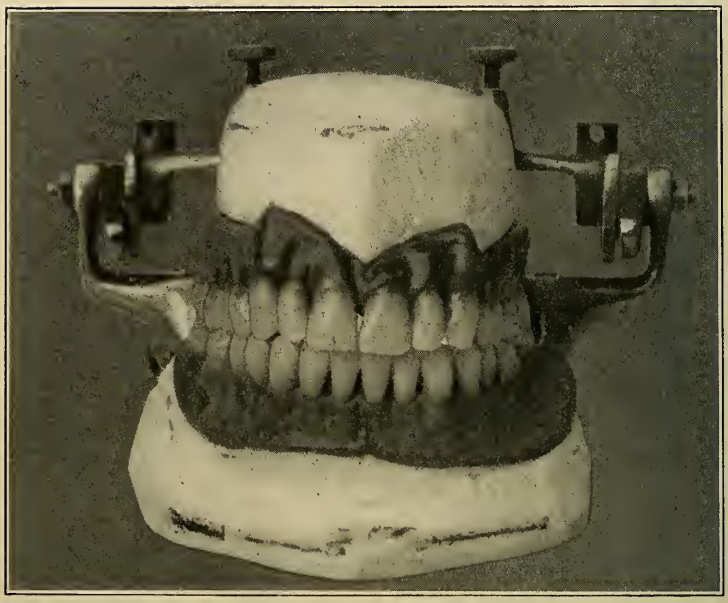
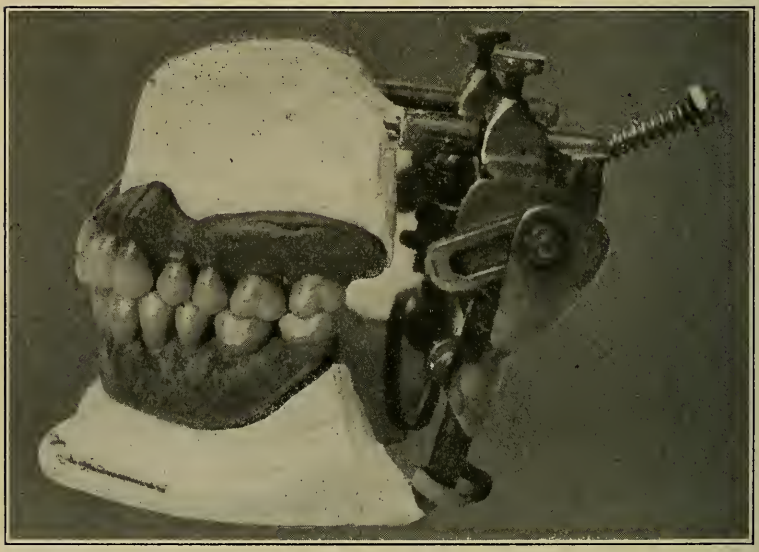


Fig. 386



respect the artificiality of the dentures is more conspicuous than in the old ones.

Figs. 378 and 379 present two views of a patient; the one upon the left shows the upper of a gum section set that had

Fig. 387

been worn for thirty years. The gum portion shows also the undersized youthful appearance of the teeth. The lower teeth are entirely out of sight. The mouth is much better restored in the view upon the right. While the dentures in

Fig. 388

Fig. 389

Fig. 390

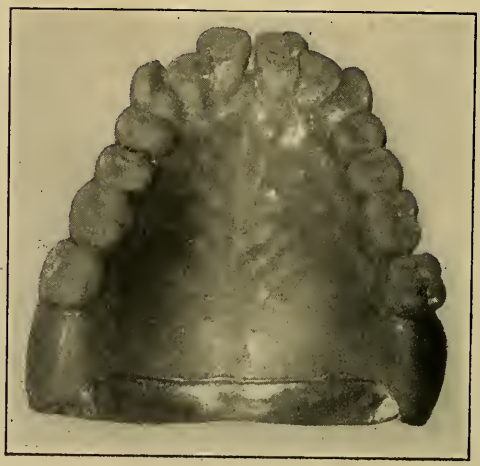


Fig. 391

Fig. 392

Fig. 393

Figs. 380 and 381 are not the ones in the patient's mouth, they are almost duplicate.

Figs. 382 to 387 show the patient and teeth constructed to the mouth of the Williams truebite teeth. The teeth were all stained except the upper second molars, which were left unstained to show the change produced by staining. The effects can be seen in the photos, but it is doubtful if it will be apparent in the half-tones.

Fig. 394

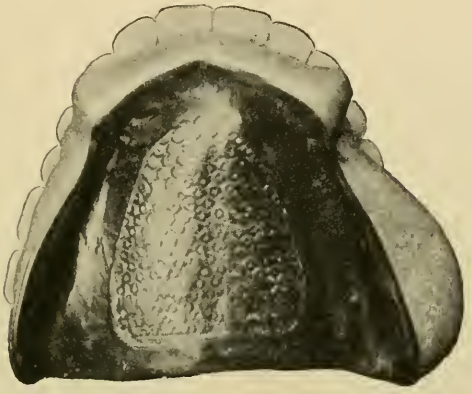
Fig. 395

Figs. 388 to 391 show different phases of esthetic restoration in continuous gum work. This is the completed case the skeleton of which is shown in Figs. 323 and 324.

Figs. 392, 393, and 394 are views of a continuous gum upper and cast metal lower that has been doing service for

some years. The dentures had been worn four years when the photos were taken.

Fig. 396



Figs. 395 and 396 are two views of a case, requiring a unilateral restoration, of a crescent-shaped face viewed from the front.

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